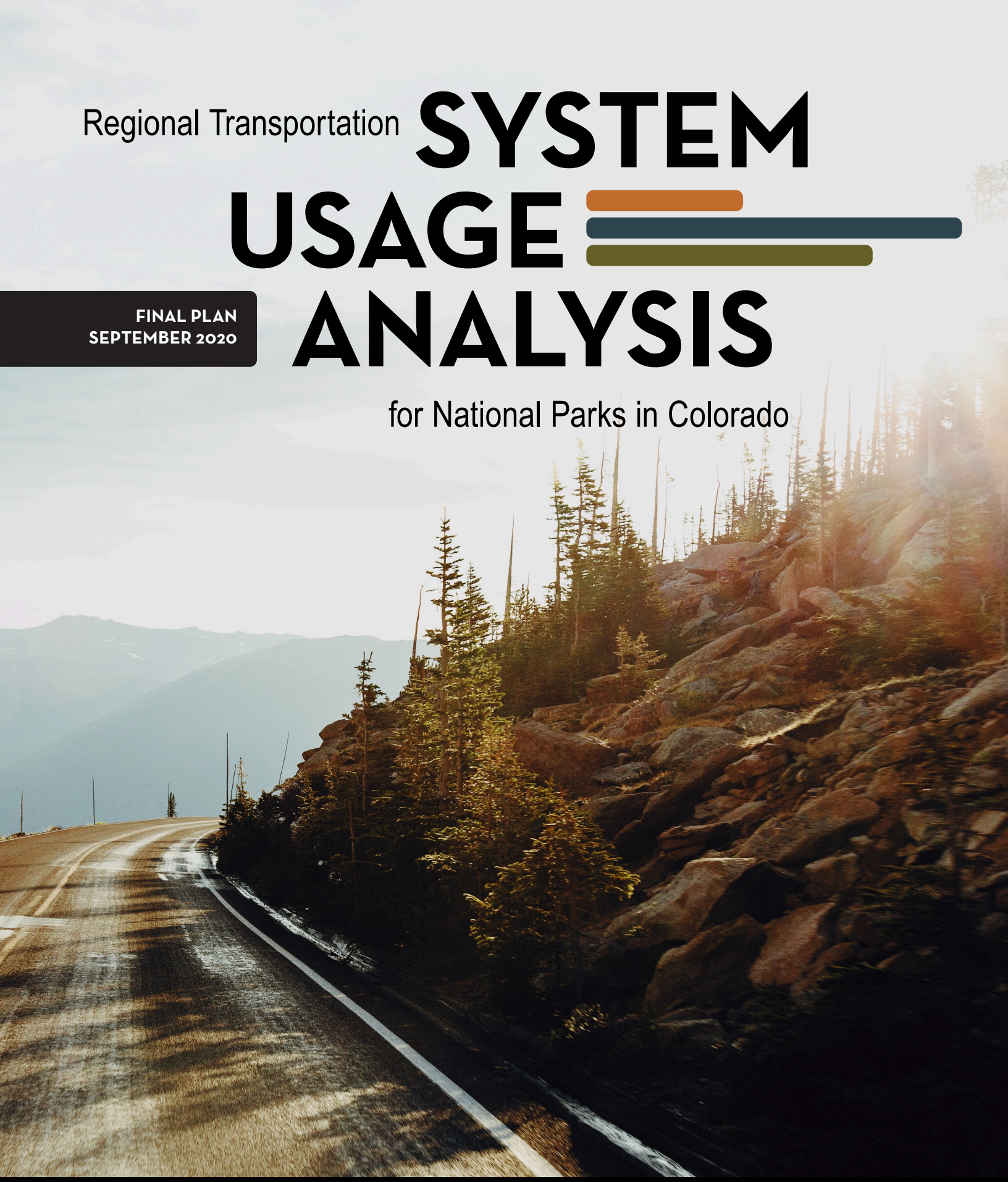
Regional Transportation

SYSTEM USAGE ANALYSIS

for National Parks in Colorado

FINAL PLAN
SEPTEMBER 2020



Regional Office Serving
Interior Regions 6, 7 & 8

National Park Service
U.S. Department of the Interior

ACKNOWLEDGMENTS

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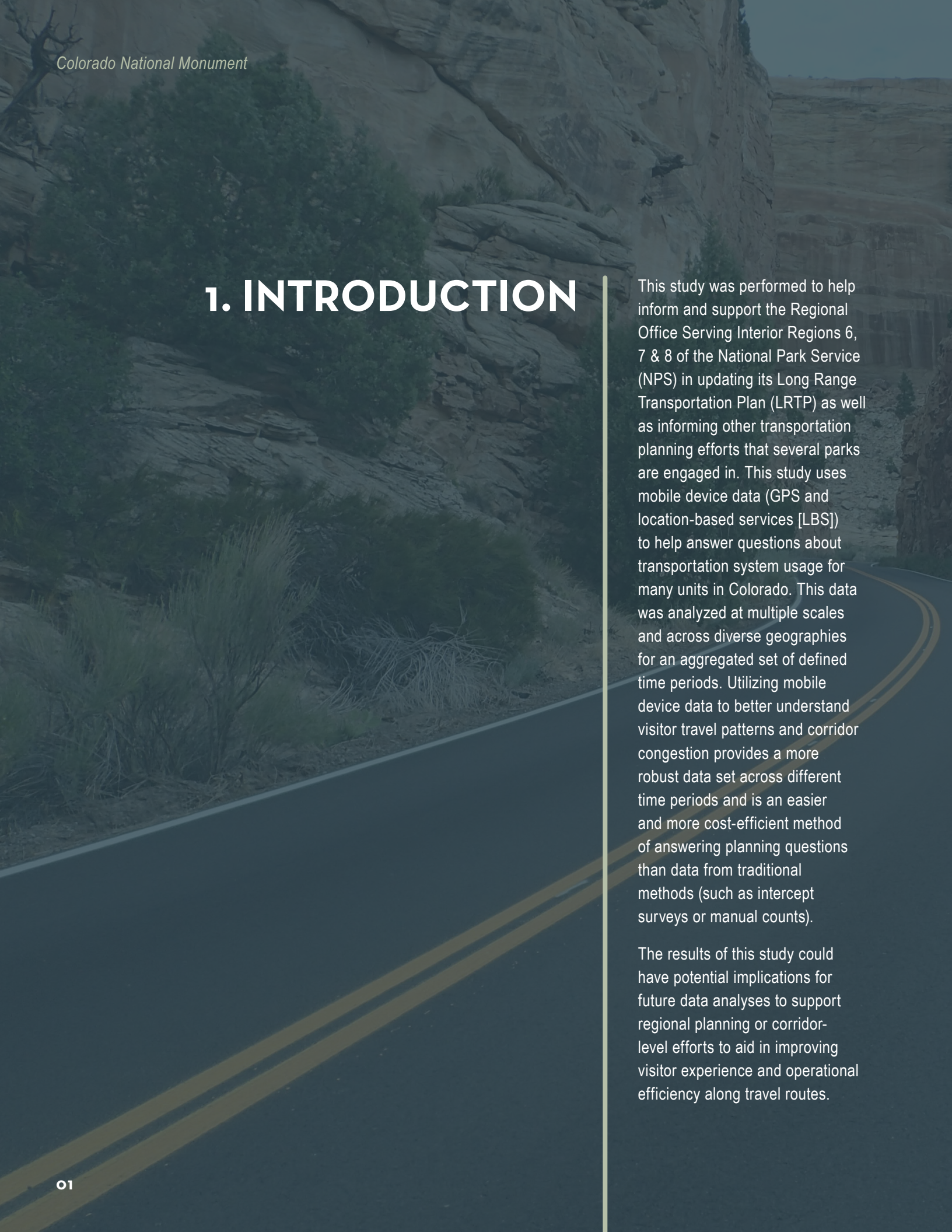
TABLE OF CONTENTS



Colorado National Monument

1. INTRODUCTION

This study was performed to help inform and support the Regional Office Serving Interior Regions 6, 7 & 8 of the National Park Service (NPS) in updating its Long Range Transportation Plan (LRTP) as well as informing other transportation planning efforts that several parks are engaged in. This study uses mobile device data (GPS and location-based services [LBS]) to help answer questions about transportation system usage for many units in Colorado. This data was analyzed at multiple scales and across diverse geographies for an aggregated set of defined time periods. Utilizing mobile device data to better understand visitor travel patterns and corridor congestion provides a more robust data set across different time periods and is an easier and more cost-efficient method of answering planning questions than data from traditional methods (such as intercept surveys or manual counts).

The results of this study could have potential implications for future data analyses to support regional planning or corridor-level efforts to aid in improving visitor experience and operational efficiency along travel routes.

GOAL

Enhance NPS transportation planning efforts by understanding appropriate and cost-effective applications of mobile device data collection

OBJECTIVES

The objectives of the study are to understand:

1. Confirm or update NPS assumptions about how visitors are utilizing park transportation networks through space and time
2. Where visitors enter the study area and what other key regional destinations are a part of their trip
3. How travel patterns of local visitors (with Colorado home locations) differ from non-local visitors (with home locations outside of Colorado)
4. Report travel patterns and dwell times by time of day, day of week, peak season, shoulder season, and off-peak

PROCESS

This study began with a collaborative exploration of potential data sources and applications for the NPS, as well as existing data sources against which to compare mobile device data obtained in the course of this study. This process was distilled into a Data Collection Plan and Data Evaluation Plan that respectively lay out attributes of the data to be collected and their applications; geographies for which different types of data should be collected, and methods for assessing and validating data obtained from vendors.

Because vendors' data products may vary substantially in their level of detail across space and time, as well as applicability to different geographic scales and types of travel, establishing these parameters from the outset of the project allowed the team to more effectively assess potential data sources and hone in on the most suitable and cost-effective vendors for this project.

Once data vendors, geographies, and evaluation methodologies were chosen, the project team reached out to key data vendors. The prior process had already narrowed down the potential set of vendors substantially, leading us to investigate three primary data providers through a combination of exploration through online data portals and conversations with vendor technical personnel regarding custom data purchase options. Of these, StreetLight Data and INRIX were selected as appropriate data sources, while a third vendor was ultimately determined not to be suitable for this project, due to coverage/spatial resolution issues in the sparsely populated areas in which Colorado's national parks and gateway communities are commonly situated.

After negotiating and finalizing data packages for purchase from these vendors, Fehr & Peers obtained the data products from each vendor and conducted extensive post-processing of trip, tour, dwell time, and congestion data products in order to produce a variety of data deliverables, ranging from summary statistics and high-level indicators of statewide and park-level travel behavior to highly focused analyses of activity at specific locations, time periods, and demographics. Early results were presented in a

Florissant Valley

virtual workshop to NPS, Colorado Department of Transportation (CDOT), and Volpe Center staff to help agency staff better understand these data products and their range of possible applications, and for the Fehr & Peers project team to better understand agency needs and desired use cases.

Report Outline

The remainder of this report is divided into five sections:

Section 2: Geography and Vendor Selection provides an outline of the NPS units, gateway communities (including Front Range cities and metro areas), internal and external corridors, and internal points of interest for which data was gathered, as well as the process of evaluating different potential data vendors to determine whether their offerings were appropriate and cost-effective means of accomplishing the project's goals.

Section 3: Data Overview provides a high-level overview of the various data types purchased and used in this project, and features a data profile for each park highlighting top-level statistics and findings. In addition, the methodologies behind custom data products are discussed, as well as limitations and parameters of this data; this information can inform future data acquisition so that purchases are closely aligned with project needs.

Section 4: Internal Travel Deep Dive, and **Section 5: External Travel Deep Dive**, present in-depth explorations of datasets relevant to internal and external travel, using Rocky Mountain National Park (ROMO) as a case study. ROMO was chosen due to its size, level of visitation, and richness of available data. The analyses in these sections provide a sense of potential applications of mobile device data products in large, heavily-visited parks; these analyses can be replicated across other NPS units wherever data availability allows.

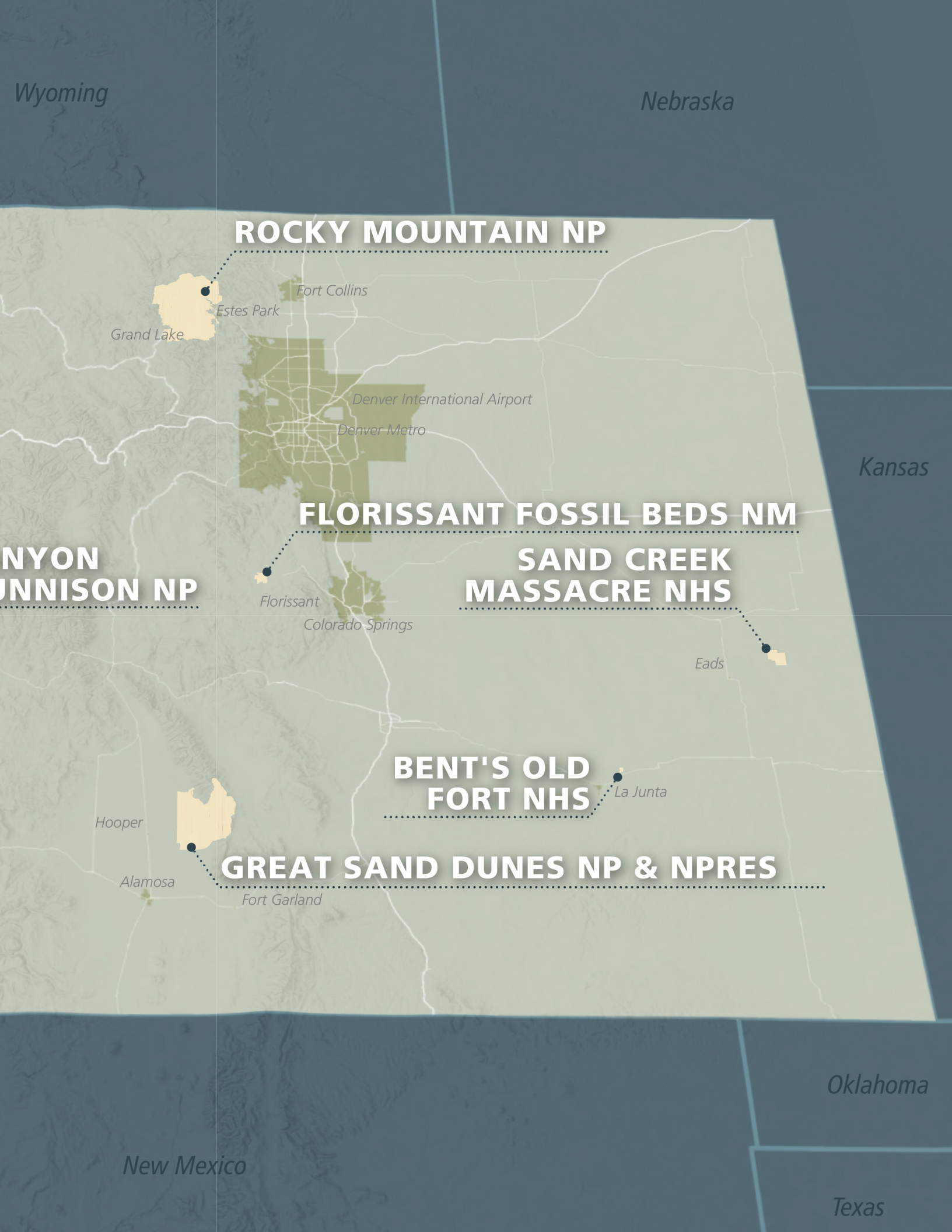
Section 6: Applications and Next Steps provides potential directions for use of the data collected in this study, as well as opportunities to leverage mobile device data in future projects beyond Colorado. It includes findings and discussion items from an inter-agency workshop held in July 2020, potential applications for various planning and park management topics, and directions for future investigation.

2. GEOGRAPHY & VENDOR SELECTION

Figure 1. Project Study Area: NPS Units and Gateway Communities

ABBREVIATION KEY

NM	National Monument
NP	National Park
NHS	National Historic Site
NRA	National Recreation Area
NPRES	National Preservation Area


Wyoming
Nebraska
ROCKY MOUNTAIN NP
Fort Collins
Estes Park
Grand Lake
Denver International Airport
Denver Metro
Kansas
FLORISSANT FOSSIL BEDS NM
NYON
UNNISON NP
SAND CREEK
MASSACRE NHS
Florissant
Colorado Springs
Eads
BENT'S OLD
FORT NHS
La Junta
Hooper
GREAT SAND DUNES NP & NPRES
Alamosa
Fort Garland
Oklahoma
New Mexico
Texas

The project team collaboratively identified a set of geographies that meet the study's goals in a cost-effective manner. The final set of study area geographies included:

13 NATIONAL PARK SERVICE UNITS:

- Bents Old Fort NHS
- Black Canyon of the Gunnison NP
- Colorado NM
- Curecanti NRA
- Dinosaur NM
- Florissant Fossil Beds NM
- Great Sand Dunes NP and Preserve (treated as one unit)
- Hovenweep NM
- Mesa Verde NP
- Rocky Mountain NP
- Sand Creek Massacre NHS
- Yucca House NM

23 GATEWAY COMMUNITIES:

- Alamosa
- Blanding
- Bluff
- Colorado Spring
- Cortez
- Delta
- Denver International Airport
- Denver metro area (DRCOG)
- Eads
- Estes Park
- Florissant
- Fort Collins
- Fort Garland
- Fruita
- Grand Junction
- Gunnison
- Hooper
- La Junta
- Mancos
- Monticello
- Montrose
- Vernal

10 COLORADO WELCOME CENTERS:

- Alamosa
- Burlington
- Cortez
- Dinosaur
- Fort Collins
- Fruita
- Julesburg
- Lamar
- Silverthorne
- Trinidad

85 INTERNAL POINTS OF INTEREST (POIS),

including visitor centers, trailheads, day use areas, campgrounds, and scenic overlooks within the following parks:

- Black Canyon of the Gunnison NP
- Colorado NM
- Curecanti NRA
- Dinosaur NM
- Mesa Verde NP
- Rocky Mountain NP

32 ROADWAYS THAT PROVIDE ACCESS TO/FROM AND/OR WITHIN THE PARKS

Great Sand Dunes National Park

VENDOR EVALUATION

At the outset of the project, Fehr & Peers conducted a high-level review of more than a dozen known data vendors, based on prior assessments, interviews, and project experience. From this universe of data providers, three vendors were quickly identified as strong candidates for providing useful data to accomplish this study's goal: StreetLight Data, a cellular data provider, and INRIX.

Two major providers of origin/destination data were evaluated: StreetLight Data and an additional cellular data provider. StreetLight Data products consist of aggregated and anonymized location data gathered from mobile devices, including commercial/in-vehicle GPS systems and location-based services (LBS). The cellular data provider aggregates travel patterns based on the location of individual devices over time (estimated based on cell tower triangulation). By tracking recorded locations of a given device over time, GPS, LBS, and cellular data products provide an understanding of trip characteristics including the origin and destination, speed, inferred mode, and route. Aggregated trips between origin and destination geographical areas, such as municipal or Park boundaries, traffic analysis zones (TAZs), and Census geography, can be obtained in the form of trip matrices of both observed trips in the dataset, and estimated total trips interpolated based on count data.

The trip matrices generated by these mobile device data products can be segmented along a number of variables to allow for more detailed analyses of travel behavior that differs by time or user group. These variables include:

- Time of day (by the hour)
- Day of week or weekday vs. weekend
- Month or season
- Traveler demographic characteristics
- Vehicle type (passenger, commercial, Transportation Network Company (TNC), based on the type of app providing data)
- Whether the trip passed through a given area or 'middle filter'

Pricing models for these data sources vary between providers but are based on factors including the number of origin/destination zones and/or the population of the study area.

StreetLight and the other cellular data provider contributed data suited to distinct but overlapping use cases. Because StreetLight's origin/destination data is based on multiple sources, including GPS-derived locations, it has a high degree of spatial precision, making these sources useful for understanding travel between small areas, accurately distinguishing between trips to adjacent zones, and picking up short-distance trips. However, it also tends to reflect a smaller sample size than cell-tower-based data. The other cellular data provider derives data from cell tower triangulation, which captures a potentially much larger and more representative sample size of the traveling public, and is well suited to applications in which tracking unique devices over long time periods and travel distances is important. However, as the single source of data used in this product, cellular data provides a lower level of spatial resolution, making it better suited for understanding travel patterns between large, distant areas; it also will fail to capture travel data in areas without cell phone service, which may be a concern in rural and wilderness areas and mountainous terrain.

Initially, the project team approached each of these vendors to understand how NPS' goals (including study area geographies and traveler/trip type disaggregation) aligned with the capabilities of each vendor's data products. In the course of evaluating potential data packages for internal and external travel, the project team determined that cell tower based data sources had critical limitations for this project's use cases. Due to this product's reliance on a high geographic density of cell towers in order to determine device locations with a high degree of precision, understanding travel in the sparsely-populated rural settings where many Colorado NPS units are located presents a significant challenge. In several cases, devices located in gateway communities and adjacent NPS units could not be accurately distinguished from each other, since they were served by the same cell tower. Due to these limitations, the project team determined that cell tower-based data was not suitable for this project. A custom data purchase from StreetLight Data was therefore determined to be the best solution to providing origin/destination data for this project. It should be noted that the selected data sources for

Rocky Mountain National Park

this project were the best fit for the specific questions and geographies of interest to this study; other locations and research questions may lend themselves to other data sources.

A primary vendor for congestion and travel time data is INRIX Analytics, which provides estimates of congestion, travel times and speeds, and related metrics on a road segment level. INRIX's data products are based on aggregated GPS probe data from commercial vehicles and in-vehicle passenger navigation systems and mobile phone applications, which provide real-time and historical estimates of vehicle speed. Because commercial vehicles are legally limited within NPS units, estimates of travel times, speeds, and congestion metrics will be primarily driven by data derived from passenger vehicles and mobile applications. By comparing measured speeds at a given time against historical or reference values, congestion and slowdowns can be identified on individual road segments as well as along longer routes or corridors. INRIX's data analysis platform provides metrics such as typical speeds, typical travel times, and planning time1 (reflecting worst-case conditions along a corridor for a given time period), as well as identifying bottleneck locations along corridors.

INRIX travel time and congestion data can be segmented by variables include:

- Time of day (by the minute)
- Day of week or weekday vs. weekend
- Month or season
- 5th, 25th, 50th, 75th, and 95th percentile conditions

Understanding variability in congestion may be of particular importance in distinguishing where slowdowns and congestion are caused by intermittent factors (e.g., stopping to view wildlife) vs. persistent factors (e.g., bottlenecks due to geometric constraints and/or high traffic volumes relative to roadway capacity during peak periods of arrivals and departures).

Based on prior evaluations of INRIX speed data compared to other available vendors the project team has found that INRIX's data product has several advantages compared to other vendors, including availability of historic data, high levels of spatial and temporal detail, inclusion of bottleneck location analysis tools, user-friendly web-based interface, and a simple pricing structure.

[1] https://ops.fhwa.dot.gov/publications/tt_reliability/TTR_Report.htm#planning

3. DATA OVERVIEW

DATASETS

Two vendors provided the datasets discussed in this report:

- StreetLight Data provided origin-destination, internal trip tour, dwell time, and corridor-level congestion data
- INRIX Analytics provided detailed segment-level congestion and bottleneck data

Each component of these datasets, including methodology and assumptions, is discussed in this section.

EXTERNAL ORIGIN-DESTINATION DATA

Vendor: *StreetLight Data*

Time: *2018-2019*

Geographies: *NPS units, Gateway Communities, Colorado Visitor Centers*

Disaggregations: *Colorado Residency, Day Type, Time of Day, Season, Year*

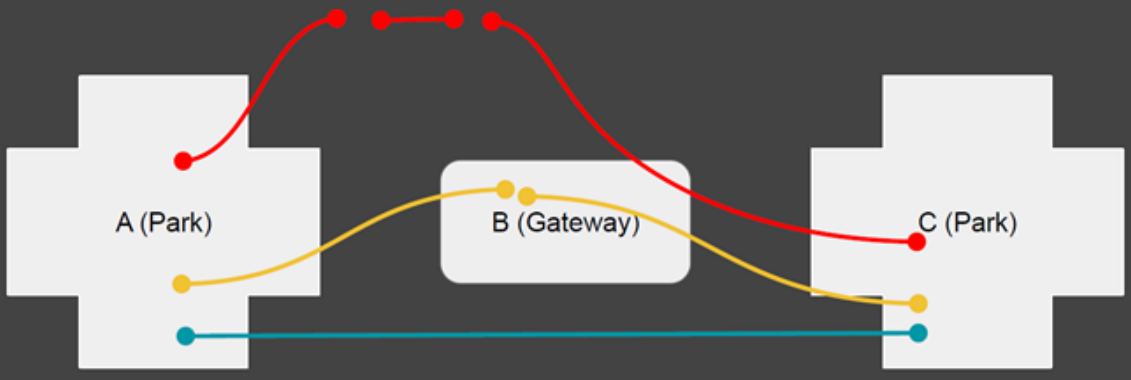
Unit: *Observed trips between origin-destination pair*

Sample Size: *1,741,561 trips*

The external origin-destination (O/D) dataset provides all trips between parks, gateway communities, and Colorado Visitor Centers during the 2018-2019 time period. For trips to be eligible for inclusion in this dataset, the device must be detected within at least one of the NPS units during the month in which the trip occurred.

Because NPS units are often located in rural areas and frequently generate long-distance trips, the standard StreetLight trip definition would typically undercount trips to and from these locations. For example, a visitor traveling from Denver to Curecanti NRA, which might take 4 to 5 hours, would likely make at least one stop, such as at a gas station, rest stop, restaurant, or other intermediate location. These stops often result in the first trip ending and a new trip being generated. In order to avoid this issue, StreetLight generated a tour-based dataset that combined successive trips within a single day that begin and end within analysis geographies. Examples of how these tours are assembled and reported in the external O/D dataset are shown in the graphic below.

Figure 2. Origin and Destination Inter Park Travel



Observations within the month

Tour	Origin	Destination
Red	A	B
Red	B	C
Yellow	A	B
Yellow	B	C
Teal	A	C

Metrics Output

Origin	Destination	Count
A	B	2
A	C	1
B	C	2

INTERNAL TRIP SEQUENCES DATA

Vendor: *StreetLight Data*

Time: *2018-2019*

Geographies: *Internal Points of Interest (POIs)*

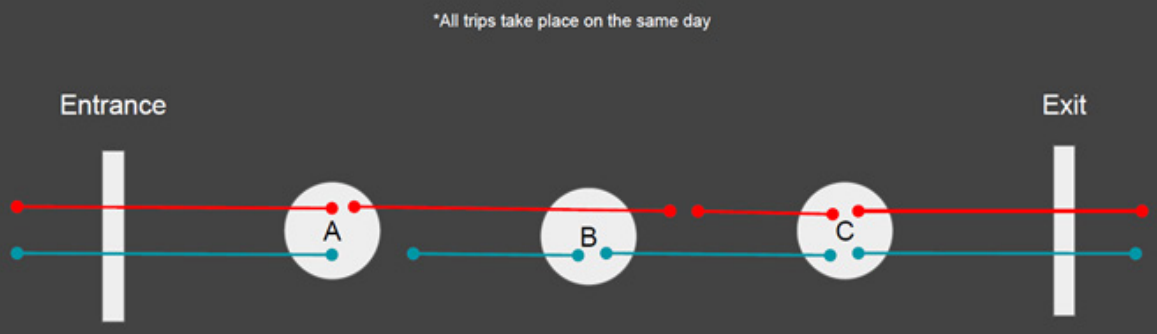
Disaggregations: *Colorado Residency, Day Type, Time of Day, Season, Year*

Unit: *Observed instances of unique trip sequences*

Sample Size: *195,582 tours including 310,568 POI stops*

The internal origin-destination (O/D) dataset provides data on all observed internal trips between internal points of interest within individual NPS units during 2018 and 2019. Instead of origin-destination volumes, which do not provide any information on the previous and following trips, this data was formatted as unique sequences of stops. A trip sequence is defined as a set of stops at designated internal POIs. These sequences may be as short as a single observed stop, or as long as 15 successive stops. Sequences may include the same point of interest multiple times, so long as all POIs were visited during the same calendar day. As shown in the teal example in the graphic below, a trip in which a device's location is unavailable (e.g. app turned off) for a period of time between POIs is still treated as a sequence if the gap is less than 1/2 mile or 24 hours after the prior stop began.

Figure 3. Internal Park Sequence Metrics



Observation

Tour	Park	Sequence
Red	ROMO	Entrance_A_C_Exit
Teal	ROMO	Entrance_A_B_C_Exit

DWELL TIME DATA

Vendor: *StreetLight Data*

Time: *2018-2019*

Geographies: *Internal POIs Gateway Communities*

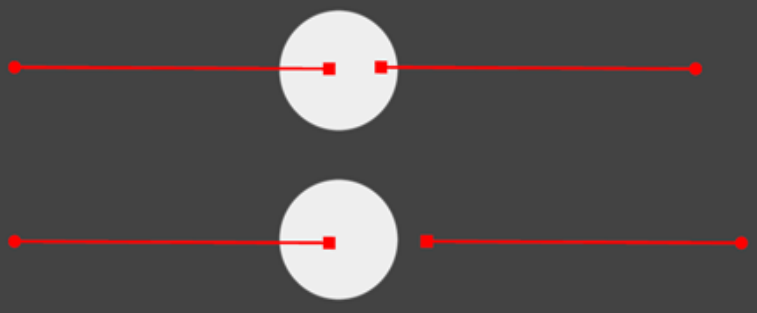
Disaggregations: *Colorado Residency, Day Type, Time of Day, Season, Year*

Unit: *Observed devices at each geography, average dwell time (minutes), percentage of trips falling into ten dwell duration bins.*

Sample Size: *3,771,887 trip ends and 3,624,117 stop durations*

The dwell time dataset provides data on the number of device trip ends observed at each internal POI and gateway community geography, and the amount of time spent at that location by devices at each location. Dwell time is provided both in an aggregate average, as well as in bins ranging from 0-5 minutes at the low end to >12 hours at the high end. Dwell time is measured as the time elapsed between the end of one trip and the beginning of the next trip. In order to ensure dwell times are not overestimated due to data gaps, any trip end in which the subsequent trip begins over half a mile away from the last trip end, or more than 24 hours later than the end of the last trip, is excluded from the dataset.

Figure 4. Zone Activity (ZA) and Dwell Time



T1 Observation	T2 Observation	Trip 1 End Time	Trip 2 Start Time	Dwell Time
End in POI	Start in POI	10:00 AM	11:00 AM	1 hour
Start in POI	Start near POI	10:00 AM	11:00 AM	1 hour

*This shows two scenarios for our observations. Actual output will show count of devices observed at each zone, the average dwell time and the dwell time distribution. Pass though zones will only include a count.

CONGESTION DATA

Vendor: *StreetLight Data, INRIX Analytics*

Time: *2019*

Geographies: *Primary Roadways*

Disaggregations: *Day Type, Time of Day, Season*

Unit: *StreetLight: Average Travel Time, Free Flow Factor, percentage of trips falling into 10 speed bins* ***INRIX: Congestion event extent, direction, average and maximum duration, average and maximum queue length***

Sample Size: *StreetLight: 633,548 trips. INRIX: not specified*

Two congestion datasets were obtained for this project. Primary access corridors were identified for a majority of parks analyzed in this project and congestion data on these corridors was obtained from StreetLight. This dataset provides basic metrics regarding travel speeds through each corridor as an entire unit. For selected corridors in the vicinity of Rocky Mountain National Park, data was available from INRIX Analytics, which provides higher-resolution data regarding common patterns of congestion events at key bottlenecks.

For each park profile, two metrics are reported:

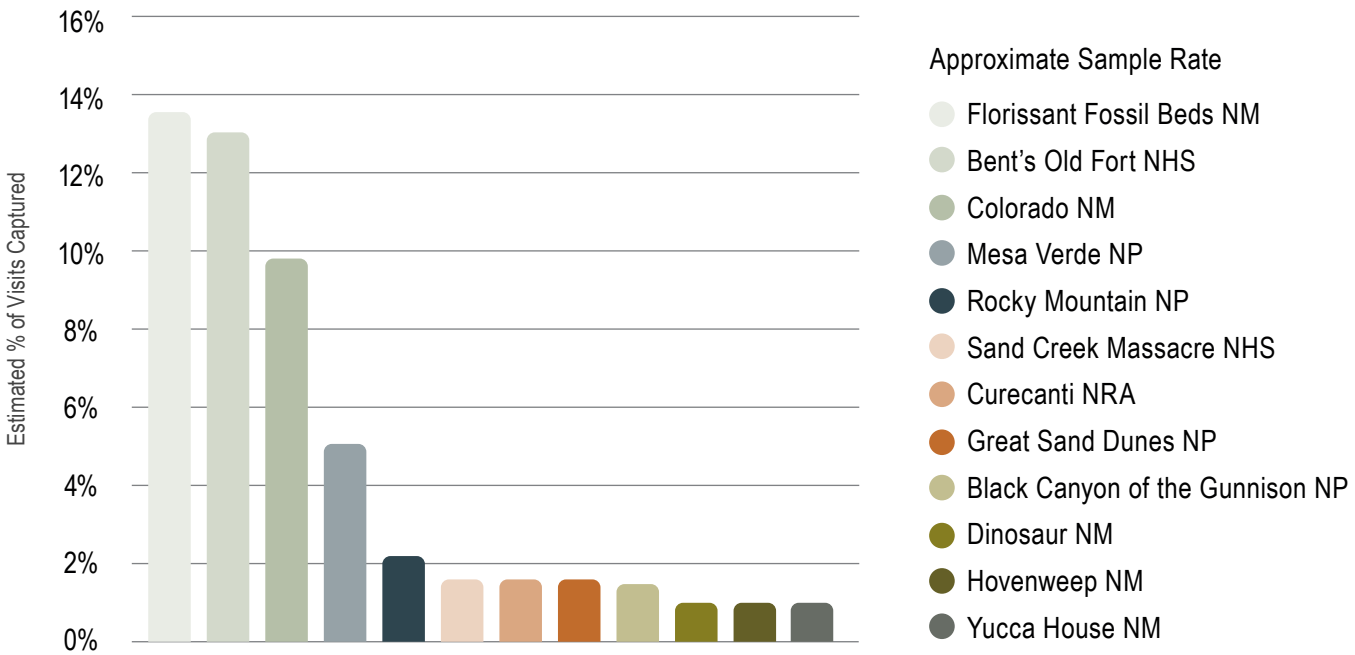
Free flow speed for each corridor is defined as the highest average trip speed observed across any one of the 24 hours of the day. This reflects speeds during the roadway's least congested typical conditions.

Each corridor's **congested speed** is defined as the average speed during AM and PM peak periods during peak season weekends. This reflects speeds during what are typically the busiest times the roadway experiences.

DATA LIMITATIONS AND CONSIDERATIONS

The data behind the four components discussed above do not provide a 100% count of activity in and around the NPS units and other geographies included in this study. The location-based services (LBS) data that underlies each of these data products depends on visitors to have

Figure 5. Estimated Trip Sample Rate



smartphones or other cellular devices powered on and running one or more applications (such as navigation, mapping, or activity tracking apps) that generate LBS data and share that data with aggregators. In this study, a comparison of park-recorded visitation against external trips measured by StreetLight showed that approximately 5.3% of park-recorded trips were included in this dataset. However, variation between parks was considerable, with three NPS units seeing over 10% of measured trips included in their sample, while others saw sub-1% sample rates.[2]

While smartphone ownership is widespread, with 81% of American adults owning one as of 2019, variation in ownership rates does exist between groups. As a result, origin-destination, trip tours, and dwell time data may under-represent visitors who are older, lower-income, have less formal education, or who live in rural areas, although none of these subgroups reported less than 50% smartphone ownership.[3] Congestion data, by contrast, typically does not encounter these issues, as traffic conditions encountered by smartphone owners in the same place and time are not expected to vary between visitors of different demographic groups.

Beyond smartphone ownership, behavioral differences in the frequency and manner of smartphone usage may exist between user groups. For example, a first-time visitor to a National Park may be more likely to use mapping or navigational apps than a local resident who has detailed familiarity with the park. Finally, although LBS-based apps have the capability to track device locations without cellular and/or data service and report these locations at the next time data service is available, users may be more likely to turn off mobile devices and/or LBS-based apps when traveling in areas with poor or non-existent cell coverage, skewing trip pattern data away from such areas.

Despite these limitations and potential sources of data bias, these data sources provide a vast amount of useful data in a cost-effective manner. The datasets obtained for this project include approximately 6.5 million data points across 13 NPS units and an entire state. Alternative sources of data, such as intercept or post-visit surveys, can provide greater qualitative nuance but are much more costly on a unit basis and present different challenges and limitations, such as survey non-response bias.

INDIVIDUAL PARK PROFILES

The following pages present key statistics and findings on usage and travel patterns to, from, and within each of the NPS units included in this study. The park profiles are presented alphabetically, with the exception of Black Canyon of the Gunnison NP and Curecanti NRA, which are co-managed and therefore presented together.

It should be noted that visitation data for Hovenweep National Monument and Yucca House National Monument did not include an adequate sample size for valid statistical analysis. Any future studies/planning efforts for these units proposing to use big data products should be vetted carefully to ensure that adequate data is available to support the intended use.

[2] Sample rates may also be affected by the proportion of overall trips to each park that travel to or from another study area geography in this dataset.
[3] Pew Research Center 2019. Mobile Fact Sheet. https://www.pewresearch.org/internet/fact-sheet/mobile/

BENT'S OLD FORT NATIONAL HISTORIC SITE

6,095 Total Observed Trips. Bent's Old Fort National Historic Site features a reconstructed 1840s adobe fur trading post on the mountain branch of the Santa Fe Trail where traders, trappers, travelers, and the Cheyenne and Arapaho tribes came together in peaceful terms for trade.

StreetLight data indicates that over 90% of visitors to Bent's Old Fort are Colorado residents, possibly indicating a limited national profile. In contrast to many Colorado parks, the off-peak winter season sees a higher volume of visits than during the summer or shoulder seasons. Weekdays and weekends see similar levels of daily visitation.

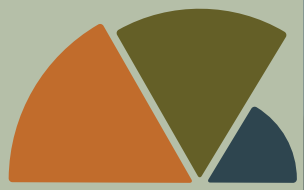
Most travelers arrive to Bent's Old Fort from La Junta. Congestion was evaluated for State Highway 194, which saw relatively small differences between peak and congested traffic speeds.

TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)

WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **41%**
- Peak (June - September) - **39%**
- Shoulder (October and May) - **20%**



WHO IS COMING?

Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

State Hwy 194

Freeflow Speed (mph)	Congested Speed (mph)
64	58

TOP 5 GATEWAYS

1	La Junta	93%
2	Colorado Springs	3%
3	Eads	2%
4	Denver Metro	2%
5	Alamosa	0.1%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

La Junta	Colorado Springs	Eads	Denver Metro	Alamosa
4:21	4:50	5:35	5:26	3:44

5,448 Total Observed Trips. Big enough to be overwhelming, still intimate enough to feel the pulse of time, Black Canyon of the Gunnison exposes you to some of the steepest cliffs, oldest rock, and craggiest spires in North America. With two million years to work, the Gunnison River, along with the forces of weathering, has sculpted this vertical wilderness of rock, water, and sky.

StreetLight data shows that over a third of visitors to the Black Canyon have arrived from out of state. Visitation is heavily concentrated during the peak summer season and is slightly higher on weekend days than weekdays. In addition to the South Rim Entrance and Visitor Center, Tomichi Point and the South Rim Campground saw high concentrations of visitor stops.

Montrose is the primary gateway to this Park, while others arrive directly from the Denver metropolitan region and Gunnison, among others. Modest levels of congestion were observed on Black Canyon Road and State Highway 347.

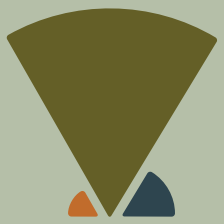
All observed entries to the Park took place at the South Rim entrance.

TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)

WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **10%**
- Peak (June - September) - **72%**
- Shoulder (October and May) - **18%**



WHO IS COMING?

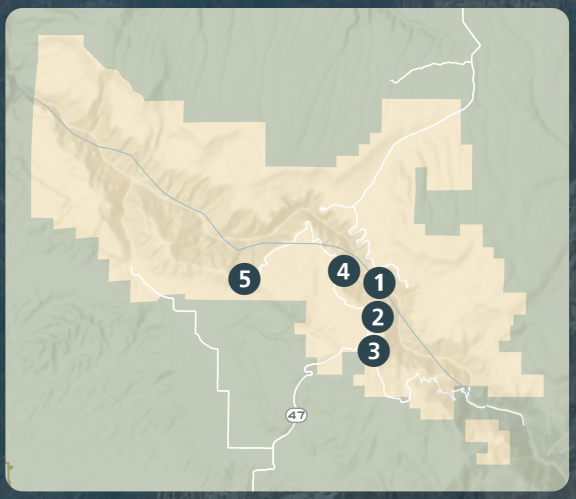
Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

	Black Canyon Rd	State Hwy 347
Freeflow Speed (mph)	38	38
Congested Speed (mph)	33	33



TOP 5 DESTINATIONS

1	South Rim Visitor Center	29%
2	Tomichi Point	15%
3	South Rim Campground	14%
4	Pulpit Rock	12%
5	High Point	10%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

South Rim Visitor Center	Tomichi Point	South Rim Campground	Pulpit Rock	High Point
0:46	0:53	8:24	0:19	0:55

TOP 5 GATEWAYS

1	Montrose	67%
2	Denver Metro	10%
3	Gunnison	6%
4	Delta	5%
5	Grand Junction	4%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Montrose	Denver Metro	Gunnison	Delta	Grand Junction
4:14	5:26	4:42	3:54	3:59

CURECANTI NATIONAL RECREATION AREA

26,827 Total Observed Trips. Curecanti National Recreation Area is a series of three reservoirs along the once wild Gunnison River. The reservoirs that make up Curecanti today are a destination for water-based recreation high in the Rocky Mountains. Best known for salmon and trout fishing, Curecanti also offers opportunities for hiking, boating, camping, and bird watching.

StreetLight data shows that approximately 8 out of 10 visitors are Colorado residents. Visitation is slightly higher on weekend days than weekdays. Limited activity was observed at internal points of interest within Curecanti NRA compared to park entrances, reflecting the dispersed nature of recreational usage.

9 out of 10 visitors arrive from the gateway communities of Gunnison or Montrose. While CO-92 and US-50 see limited congestion among recreational travelers, visitors on County Road 50F and Morrow Point Dam Road experienced heavy congestion during peak conditions.

Observed entries to the NRA were split 58% from the East Gate US-50 entrance compared to 42% at the western US-50 entrance.

TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)

WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **23%**
- Peak (June - September) - **60%**
- Shoulder (October and May) - **17%**

WHO IS COMING?

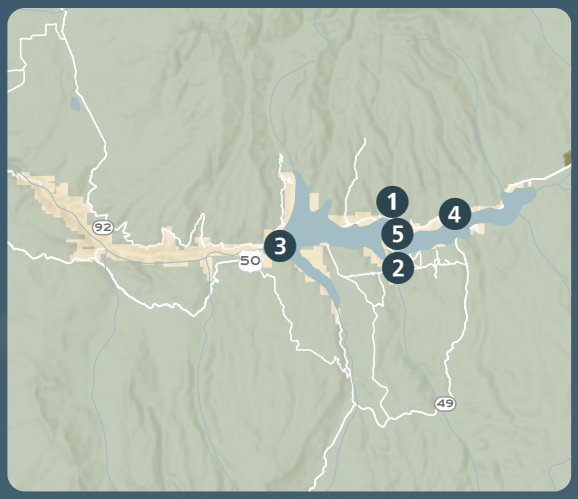
Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

	Co Rd 50F	Morrow Pt Dam Rd	State Hwy 92	US-50
Freeflow Speed (mph)	70	28	39	54
Congested Speed (mph)	20	18	37	51



TOP 5 DESTINATIONS

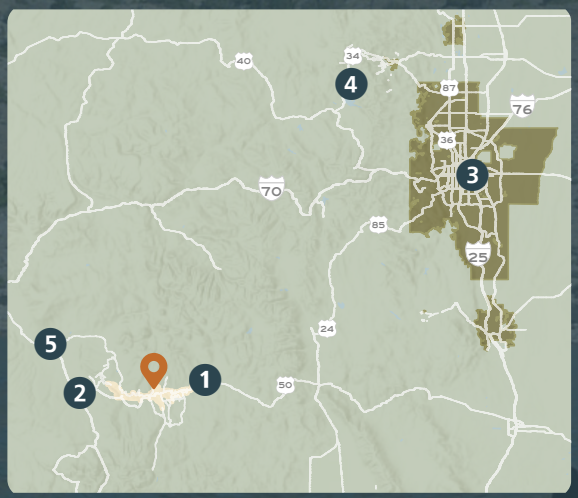
1	Elk Creek Campground	26%
2	Elk Creek Boat Launch	24%
3	Late Fork Campground	14%
4	Stevens Creek Campground	9%
5	Elk Creek Visitor Center	8%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Elk Creek Campground	Elk Creek Boat Launch	Late Fork Campground	Stevens Creek Campground	Elk Creek Visitor Center
8:44	2:20	2:40	6:11	3:52



TOP 5 GATEWAYS

1	Gunnison	55%
2	Montrose	35%
3	Denver Metro	3%
4	Grand Junction	2%
5	Delta	2%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Gunnison	Montrose	Denver Metro	Grand Junction	Delta
4:14	5:26	4:42	3:54	3:59

COLORADO NATIONAL MONUMENT

72,226 Total Observed Trips. Colorado National Monument preserves one of the grand landscapes of the American West. But this treasure is much more than a monument. Towering monoliths exist within a vast plateau and canyon panorama. You can experience sheer-walled, red rock canyons along the twists and turns of Rim Rock Drive, where you may spy bighorn sheep and soaring eagles.

StreetLight data shows that over 9 out of 10 visitors is a Colorado resident, reflecting this National Monument's role as a local recreational asset. Visitation is even across weekdays and weekend days and throughout the year. The West Entrance is the most frequently used gateway to the park in the data sample, while Cold Shivers Point and the Saddlehorn Campground are popular internal destinations.

Over 90% of visitors arrive from the Mesa County municipalities of Fruita and Grand Junction. Modest levels of congestion were observed on Monument Road and State Highway 340.

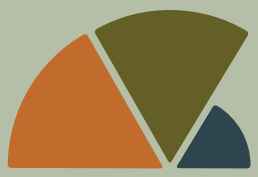
75% of observed trips entered the Monument from the West Entrance, compared to 25% at the East Entrance.

TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)

WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **41%**
- Peak (June - September) - **40%**
- Shoulder (October and May) - **19%**



WHO IS COMING?

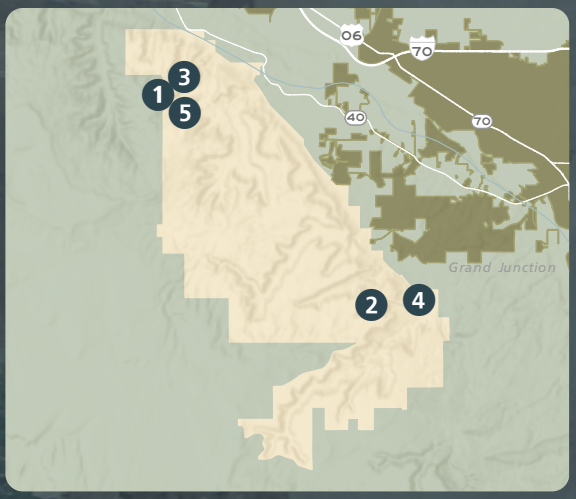
Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

	Monument Rd	State Hwy 340
Freeflow Speed (mph)	43	44
Congested Speed (mph)	36	38



TOP 5 DESTINATIONS

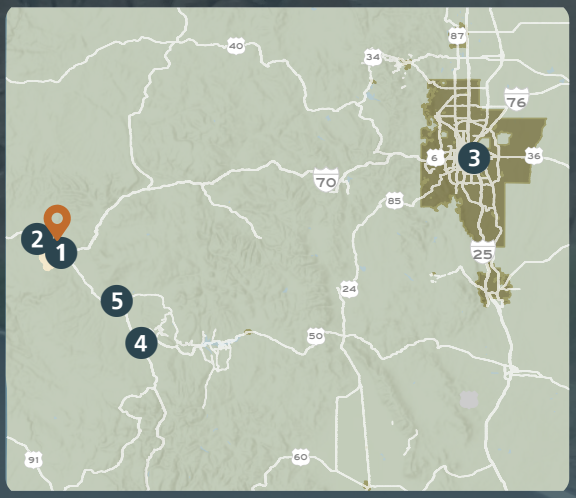
1	Visitor Center	47%
2	Cold Shivers Point Overlook	10%
3	Saddlehorn Campground	9%
4	Devil's Kitchen Picnic Area	9%
5	Independence Monument View	8%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Visitor enter	Cold Shivers Point Overlook	Saddlehorn Campground	Devil's Kitchen Picnic Area	Independence Monument View
1:00	0:23	8:42	1:10	0:40



TOP 5 GATEWAYS

1	Grand Junction	67%
2	Fruita	10%
3	Denver Metro	6%
4	Montrose	5%
5	Delta	4%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Grand Junction	Fruita	Denver Metro	Montrose	Delta
3:59	5:34	5:26	4:14	3:54

5,203 Total Observed Trips. Dinosaurs once roamed here. Their fantastic remains are still visible embedded in the rocks. Today, the mountains, desert and untamed rivers flowing in deep canyons, support an array of life. Petroglyphs hint at earlier cultures. Later, homesteaders and outlaws found refuge here. Whether your passion is science, adventure, history or scenery, Dinosaur offers much to explore.

Given Dinosaur National Monument's location on the Utah-Colorado border, it is unsurprising that StreetLight data shows a near-majority of visitors coming from outside Colorado. Visitation is fairly even between weekdays and weekend days, while the summer peak season sees higher visitation than shoulder and winter seasons. In addition to visitor and information centers, Split Mountain Campground and Harpers Corner Trailhead saw higher concentrations of visitor activity.

All observed trips entered the Monument through the Quarry Entrance Station.

TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)

WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **26%**
- Peak (June - September) - **57%**
- Shoulder (October and May) - **17%**

WHO IS COMING?

Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

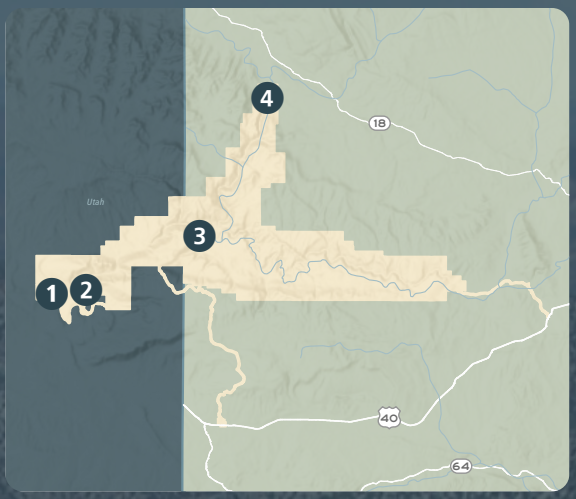
NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

Co Rd 14

Freeflow Speed (mph)	Congested Speed (mph)
23	–



TOP 5 DESTINATIONS

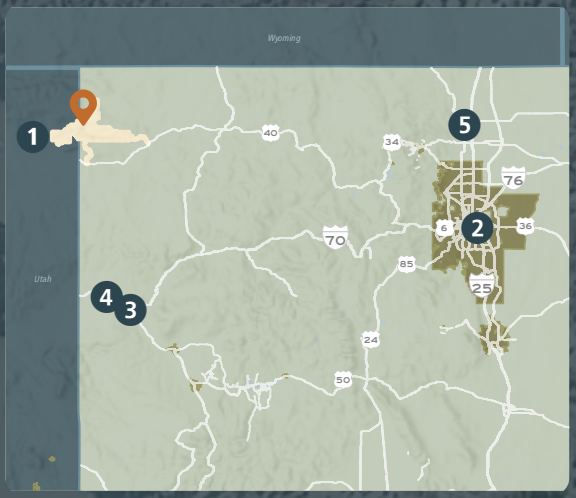
1	Quarry Visitor Center - Historic	79%
2	Split Mountain Campground	9%
3	Harpers Corner Trailhead	7%
4	Gates of Lodore Campground	5%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Quarry Visitor Center - Historic	Split Mountain Campground	Harpers Corner Trailhead	Gates of Lodore Campground
1:03	1:51	1:09	5:20



TOP 5 GATEWAYS

1	Vernal	68%
2	Denver Metro	14%
3	Grand Junction	6%
4	Fruita	3%
5	Fort Collins	3%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Vernal	Denver Metro	Grand Junction	Fruita	Fort Collins
4:42	4:14	5:26	3:59	3:54

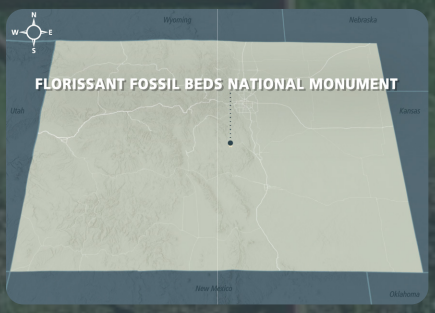
21,488 Total Observed Trips. Beneath a grassy mountain valley in central Colorado lies one of the richest and most diverse fossil deposits in the world. Petrified redwood stumps up to 14 feet wide and thousands of detailed fossils of insects and plants reveal the story of a very different, prehistoric Colorado.

StreetLight data shows that approximately 9 out of 10 visitors are Colorado residents. Visitation is fairly even across weekdays and weekend days, and the peak season sees only modestly higher levels of visitation than during shoulder and off-peak months.

Visitors commonly arrive from Colorado Springs or Florissant. Little congestion was observed in this data sample on Lower Twin Rock Road, whereas Teller County Road 1 saw modest levels of congestion during peak conditions.

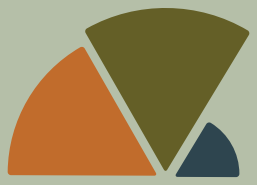
TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)



WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **39%**
- Peak (June - September) - **44%**
- Shoulder (October and May) - **17%**



WHO IS COMING?

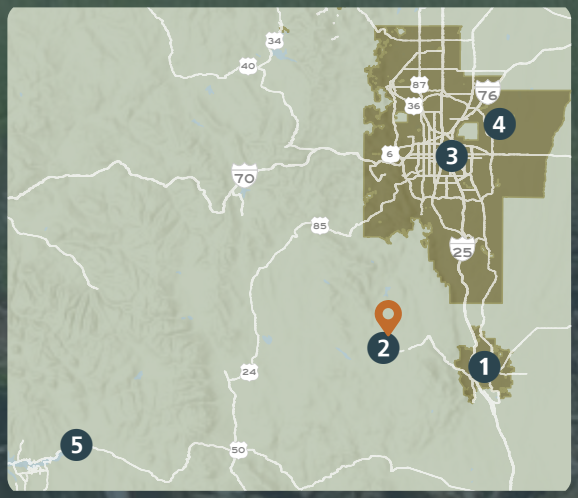
Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

	Lower Twin Rock Rd	Teller Co Rd 1
Freeflow Speed (mph)	46	49
Congested Speed (mph)	44	41



TOP 5 GATEWAYS

1	Colorado Springs	58%
2	Florissant	36%
3	Denver Metro	5%
4	Denver International Airport	0.3%
5	Gunnison	0.2%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Colorado Springs	Florissant	Denver Metro	Denver International Airport	Gunnison
4:50	2:07	5:26	1:05	4:42

GREAT SAND DUNES NATIONAL PARK & PRESERVE

12,017 Total Observed Trips. Open all day and night year round, the tallest dunes in North America are the centerpiece in a diverse landscape of grasslands, wetlands, conifer and aspen forests, alpine lakes, and tundra. Experience a starry sky on moonless nights, or a surreal walk on the dunes under bright full moonlight.

StreetLight data shows that approximately a third of visitors to Great Sand Dunes arrive from out of state. Visitation is heavily concentrated during peak times and seasons, with nearly twice as much visitation on the average weekend day than the average weekday, and a strong peak in visitation during the summer months.

Visitors come to Great Sand Dunes from a variety of locations, with trips originating at Alamosa, Fort Garland, the Denver metro area, Colorado Springs, and Hooper in significant shares. Little congestion was observed in this data sample on adjacent access routes.

TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)

WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **13%**
- Peak (June - September) - **68%**
- Shoulder (October and May) - **19%**

WHO IS COMING?

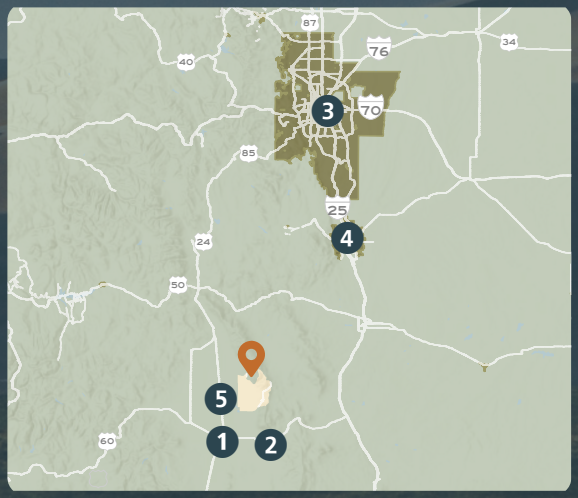
Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

	Ln 6		State Hwy 150	
Freeflow Speed (mph)	60		64	
Congested Speed (mph)		57		61



TOP 5 GATEWAYS

1	Alamosa	30%
2	Fort Garland	19%
3	Denver Metro	17%
4	Colorado Springs	15%
5	Hooper	12%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Alamosa	Fort Garland	Denver Metro	Colorado Springs	Hooper
3:44	2:11	5:26	4:50	1:36

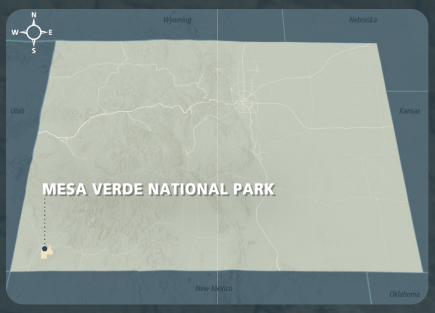
58,428 Total Observed Trips. Mesa Verde National Park was established in 1906 to preserve and interpret the archaeological heritage of the Ancestral Pueblo people who made it their home for over 700 years, from 600 to 1300 CE. Today, the park protects nearly 5,000 known archaeological sites, including 600 cliff dwellings.

StreetLight data shows that non-Colorado residents make up over 4 in 10 visits to this park. Slightly more visitors in this data sample arrived on the average weekdays than the average weekend day, and over a third of visits occur during the off-peak winter months. The most popular internal destinations in Mesa Verde include the Cliff Palace area and the Montezuma Valley Overlook.

Nearly all visitors in the sample were recorded arriving from either Cortez or Mancos. During peak times, substantial congestion was observed on Mesa Top Ruins Road (MEVA 10).

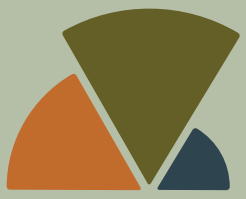
TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)



WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **35%**
- Peak (June - September) - **46%**
- Shoulder (October and May) - **19%**



WHO IS COMING?

Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

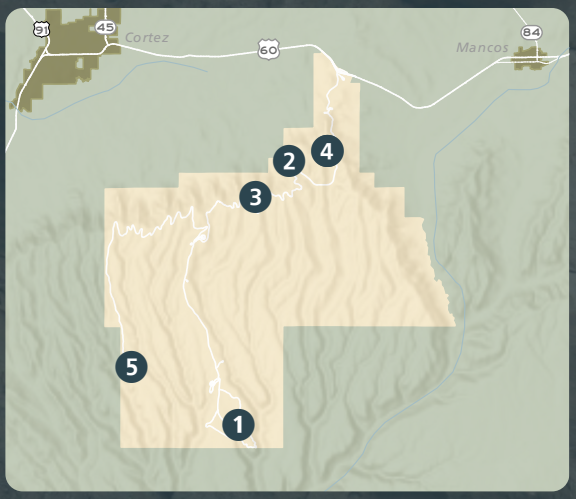
NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

MEVA 10

Freeflow Speed (mph)	Congested Speed (mph)
35	25



TOP 5 DESTINATIONS

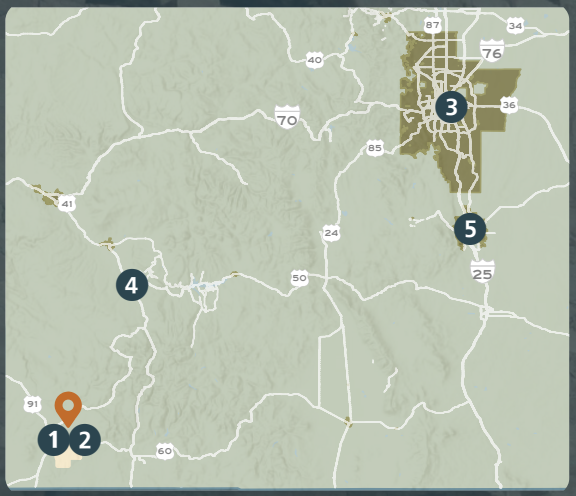
1	Cliff Palace	34%
2	Montezuma Valley Overlook	11%
3	Park Point	7%
4	Morefield Campground	6%
5	Wetherill Mesa Picnic Area	5%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Cliff Palace	Montezuma Valley Overlook	Park Point	Morefield Campground	Wetherill Mesa Picnic Area
1:16	0:22	0:28	9:24	1:32



TOP 5 GATEWAYS

1	Cortez	51%
2	Mancos	45%
3	Denver Metro	1%
4	Montrose	0.6%
5	Colorado Springs	0.6%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Cortez	Mancos	Denver Metro	Montrose	Colorado Springs
4:25	4:25	5:26	4:14	4:50

ROCKY MOUNTAIN NATIONAL PARK

201,830 Total Observed Trips. Rocky Mountain National Park's 415 square miles encompass and protect spectacular mountain environments. Enjoy Trail Ridge Road – which crests at over 12,000 feet including many overlooks to experience the subalpine and alpine worlds – along with over 300 miles of hiking trails, wildflowers, wildlife, starry nights, and fun times.

StreetLight data shows that this park's substantial visitation is split approximately 40%-60% between out-of-state visitors and Colorado residents. Visitation is fairly concentrated during weekend days and during the summer peak season. Beyond the park entrances, the Bear Lake Road corridor is the most frequently visited area of the park.

A solid majority of park visitors arrive from Estes Park, with smaller concentrations of travelers arriving from Grand Lake or the Denver metro area. Moderate levels of congestion are experienced on the various roads providing access to the Park.

For more detailed discussion of travel and usage patterns observed at Rocky Mountain National Park, see the deep dives presented in sections 4 and 5 of this document.

58% of recorded entries came through Beaver Meadows, while entries from Grand Lake made up 23%, and Fall River made up 19%.

TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)

WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **19%**
- Peak (June - September) - **67%**
- Shoulder (October and May) - **14%**

WHO IS COMING?

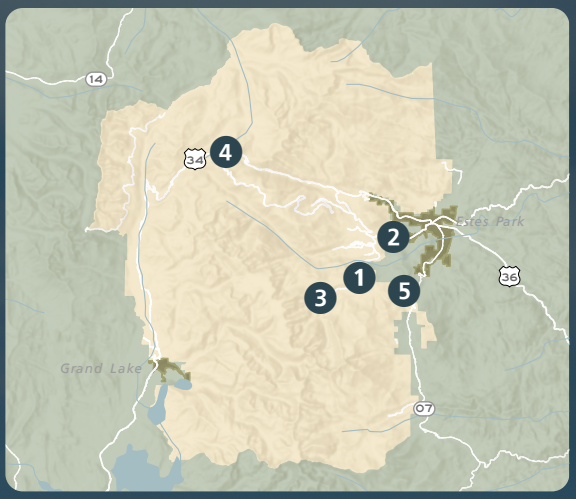
Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

	Bear Lake Rd	State Hwy 7	US-34	US-36 (Estee Park)	US-36 (Lyons)
Freeflow Speed (mph)	31	42	55	30	43
Congested Speed (mph)	26	37	50	14	34



TOP 5 DESTINATIONS

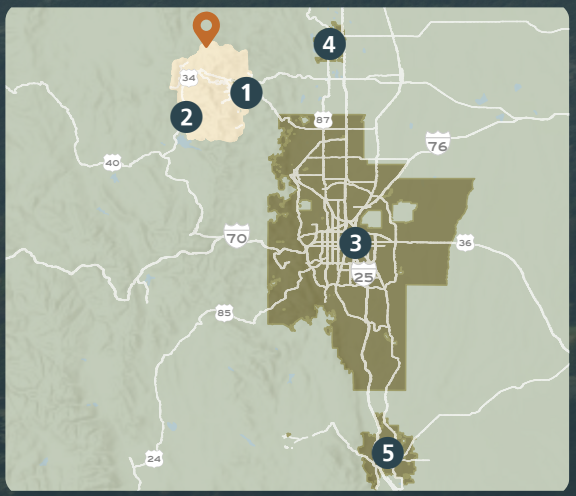
1	Bear Lake Road	34%
2	Beaver Meadows Visitor Center	11%
3	Bear Lake	7%
4	Alpine Visitor Center	6%
5	Lily Lake	5%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Bear Lake Road	Beaver Meadows Visitor Center	Bear Lake	Alpine Visitor Center	Lily Lake
2:12	0:53	1:12	0:40	1:27



TOP 5 GATEWAYS

1	Estes Park	67%
2	Grand Lake	17%
3	Denver Metro	12%
4	Fort Collins	2%
5	Colorado Springs	1%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Estes Park	Grand Lake	Denver Metro	Fort Collins	Colorado Springs
4:41	3:57	5:26	4:52	4:50

164 Total Observed Trips. The Sand Creek Massacre: profound, symbolic, spiritual, controversial, a site unlike any other in America. As 675 cavalrymen came around a prairie bend, the camps of Chiefs Black Kettle, White Antelope, and Left Hand lay in the valley before them. Chaotic, horrific, tumultuous, and bloody, the events of November 29, 1864 changed the course of history.

Data for the Sand Creek Massacre NHS is limited and the findings shown below should be used with caution. StreetLight data shows that approximately 8 in 10 visits are made by Colorado residents. Visitation is fairly concentrated during weekend days, but occurs at modest levels throughout the year.

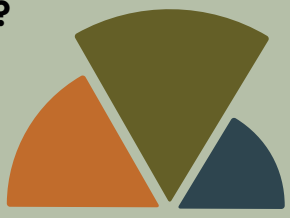
Visitors to this Historic Site arrive primarily from Eads, the Denver metro area, and Colorado Springs. Modest congestion was experienced by travelers on County Road 54; congestion was also evaluated for County Road W but insufficient data was available to evaluate congestion at this location.

TOTAL WEEKDAY VS. WEEKEND VISITATION

WEEKDAY (M-F) WEEKEND (S-S)

WHEN ARE VISITORS COMING?

- Off-Peak (November - April) - **34%**
- Peak (June - September) - **43%**
- Shoulder (October and May) - **24%**



WHO IS COMING?

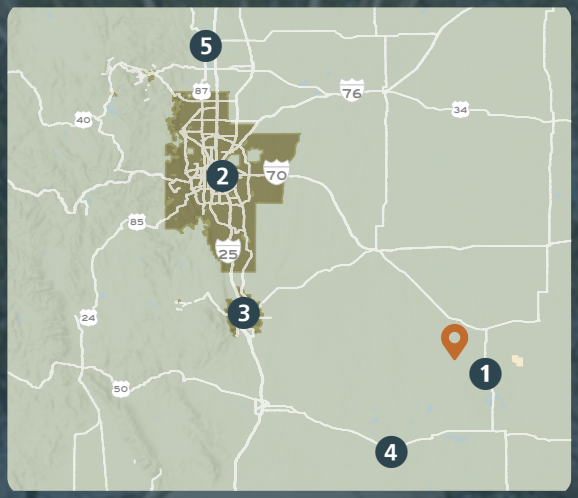
Colorado residency was inferred from the nighttime location of a device over the past month and may include long-term visitors to the state.

NON-RESIDENT RESIDENT

TRAVEL SPEED

Congested speeds based on weekend peak hours in the summer season.

	Col Rd 54	Co Rd W
Freeflow Speed (mph)	41	32
Congested Speed (mph)	36	–



TOP 5 GATEWAYS

1	Eads	47%
2	Denver Metro	30%
3	Colorado Springs	10%
4	La Junta	8%
5	Fort Collins	1%

DWELL TIMES

Reflects average duration between a trip ending in this location and the next trip beginning.

Dwell Time (H:MM)

Eads	Denver Metro	Colorado Springs	La Junta	Fort Collins
5:35	5:26	4:50	4:21	4:52

39 Total Observed Trips. Once home to over 2,500 people, Hovenweep includes six prehistoric villages built between A.D. 1200 and 1300. Explore a variety of structures, including multistory towers perched on canyon rims and balanced on boulders. The construction and attention to detail will leave you marveling at the skill and motivation of the builders.

Hovenweep National Monument was included in this dataset; unfortunately, the data provided by StreetLight was too small in terms of sample size to allow for statistical analysis of visitation patterns; this is due in part to the inclusion only of portions of the Monument within Colorado. This information should therefore be treated as a convenience sample with limited applicability to the Utah portion of the park. Most visitors were Colorado residents, and a majority arrived from Cortez. Visitation occurred throughout the year at relatively consistent levels, and was fairly balanced across the week.

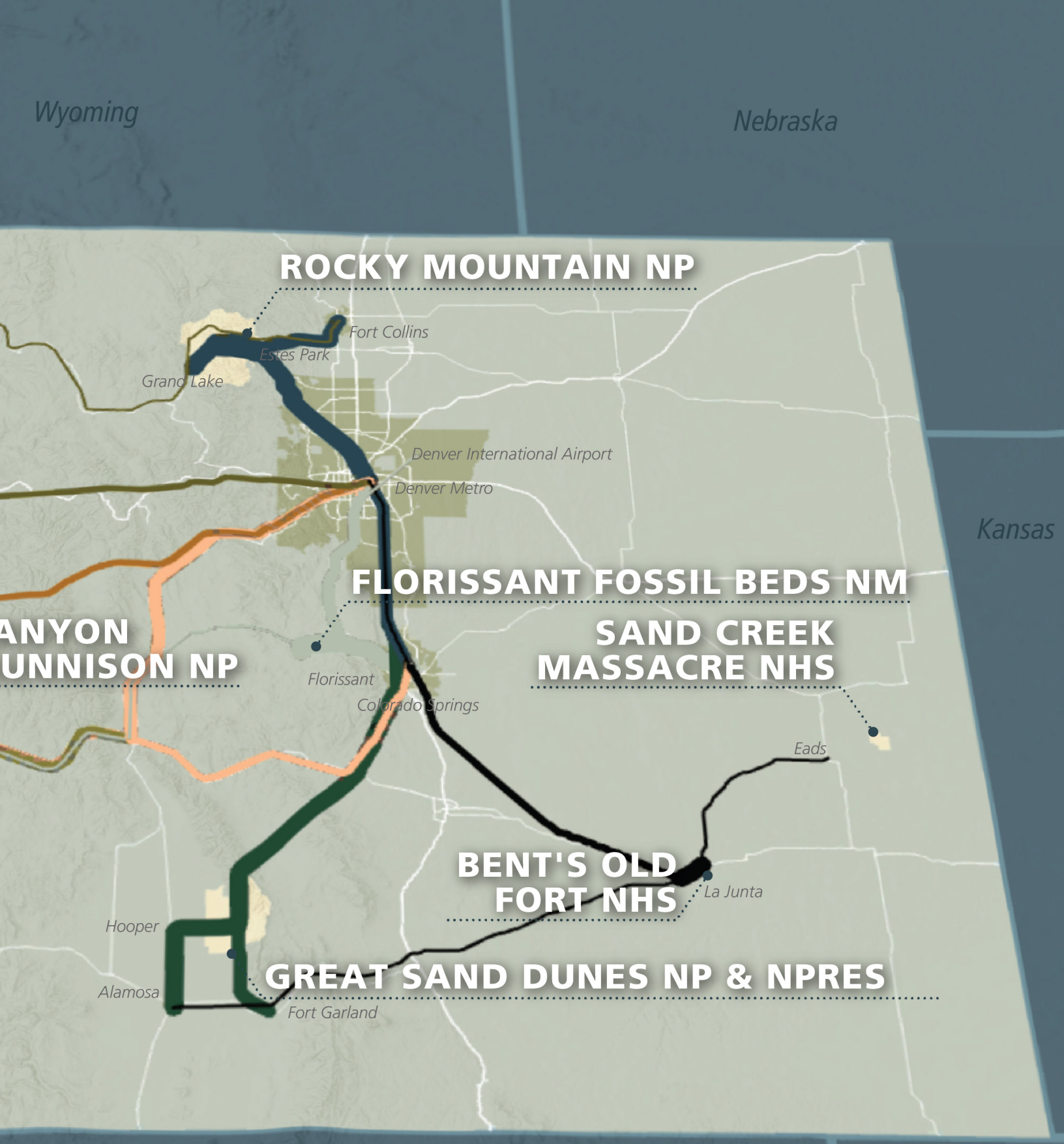
40 Total Observed Trips. Through a continuing tradition of public and private cooperation, Yucca House National Monument preserves one of the largest archaeological sites in SW Colorado. The unexcavated nature of the site preserves its integrity and beauty for future generations of scientists and visitors.

Yucca House National Monument was included in this dataset; unfortunately, the data provided by StreetLight was too small in terms of sample size to allow for statistical analysis of visitation patterns; this may be due to limited overall visitation and/or data connectivity limitations. This information should therefore be treated as a convenience sample. Most visitors were Colorado residents, and a majority arrived from Cortez. Visitation occurred throughout the year at relatively consistent levels, and was fairly balanced across the week.

Figure 6. This map shows flows of external trips between NPS units and gateway communities, as depicted in the StreetLight external origin-destination dataset. Flows of observed trips from 2018 and 2019 are shown for each of the top 5 destinations most commonly connected to each park.

ABBREVIATION KEY

NM	National Monument
NP	National Park
NHS	National Historic Site
NRA	National Recreation Area
NPRES	National Preservation Area


Wyoming
Nebraska
ROCKY MOUNTAIN NP
Fort Collins
Estes Park
Grand Lake
Denver International Airport
Denver Metro
Kansas
FLORISSANT FOSSIL BEDS NM
ANYON
UNNISON NP
SAND CREEK
MASSACRE NHS
Florissant
Colorado Springs
Eads
BENT'S OLD
FORT NHS
La Junta
Hooper
GREAT SAND DUNES NP & NPRES
Alamosa
Fort Garland
Oklahoma
New Mexico

4. INTERNAL TRAVEL FOCUS - ROCKY MOUNTAIN NATIONAL PARK

OVERVIEW

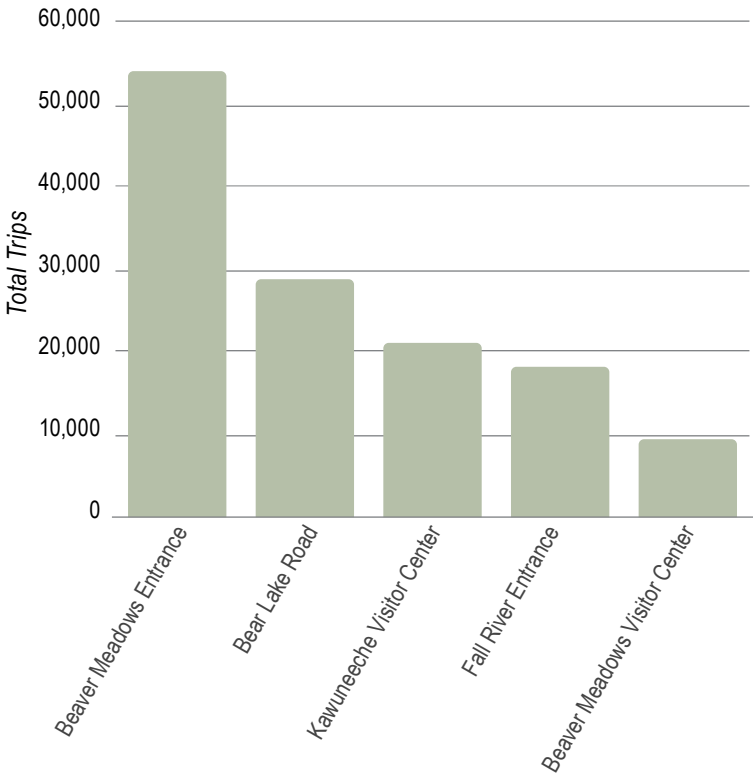
In order to explore the range of questions that mobile device data can shed light on in transportation planning and visitor use management applications, the project team conducted a deep dive into the data available for Rocky Mountain National Park (ROMO). In this section, we examine data relevant to internal travel within ROMO, including trip sequences and internal dwell times.

ROMO was chosen as the most appropriate site for this deep dive analysis due to its size, level of visitation, and richness of available data. ROMO has the largest sample size across datasets by a significant margin, which allows for more detailed examinations of differences in travel behavior across subgroups of travelers and time periods. Data presented in this and the following chapter of the report are based on a sample of approximately 2.5% of annual visits.

The analyses in these sections provide a sense of potential applications of mobile device data products in large, heavily-visited parks; these analyses can be replicated across other NPS units wherever data availability allows.

INTERNAL TRIP SEQUENCES

Figure 7. ROMO Points of Interest: Total Observed Visits **(Top 5)**



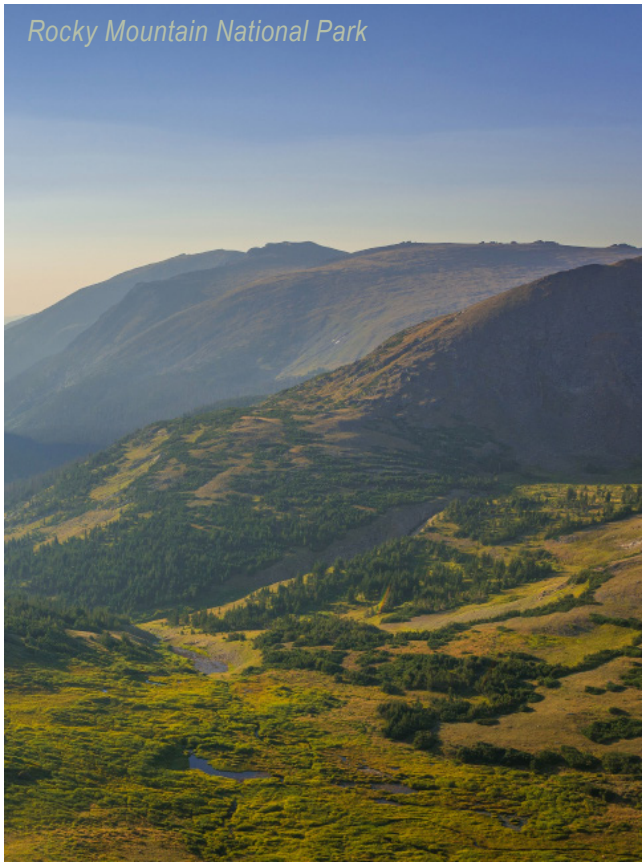
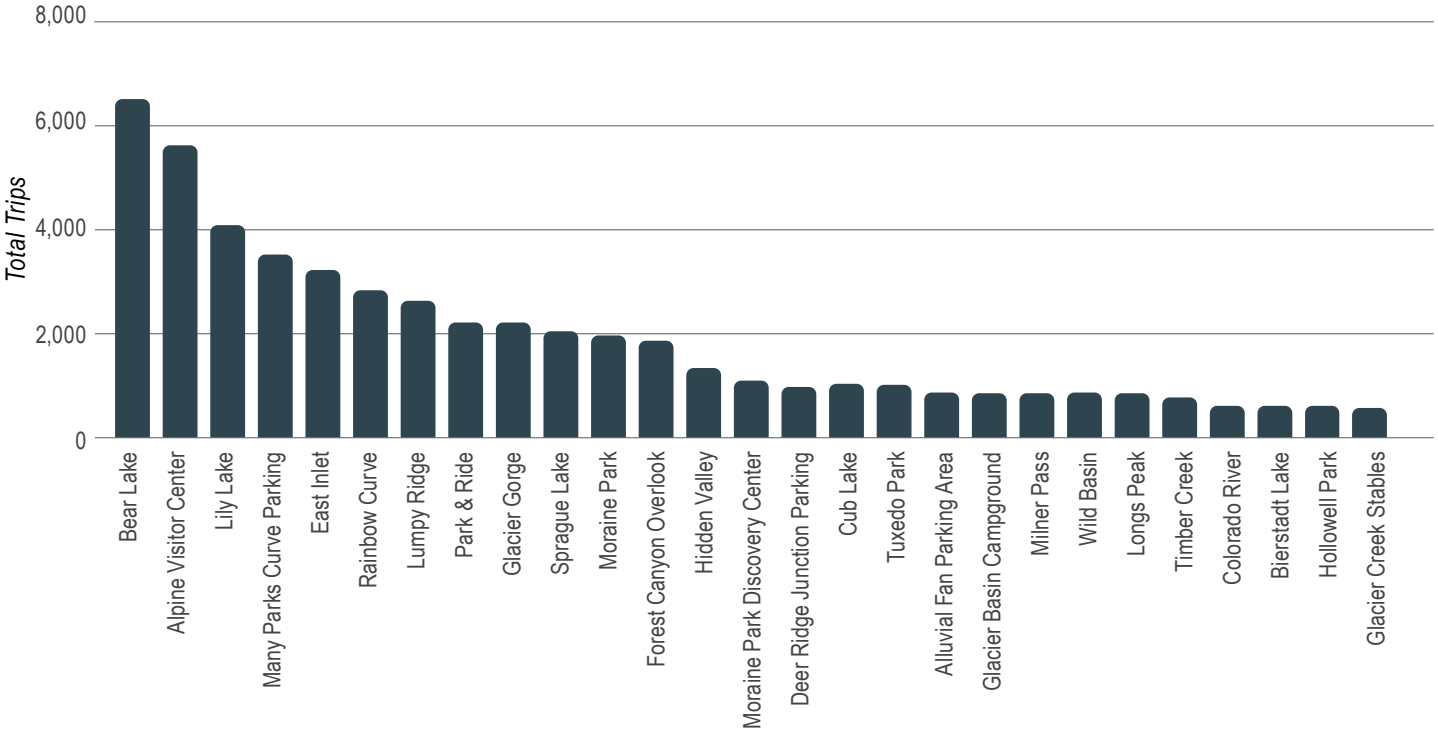


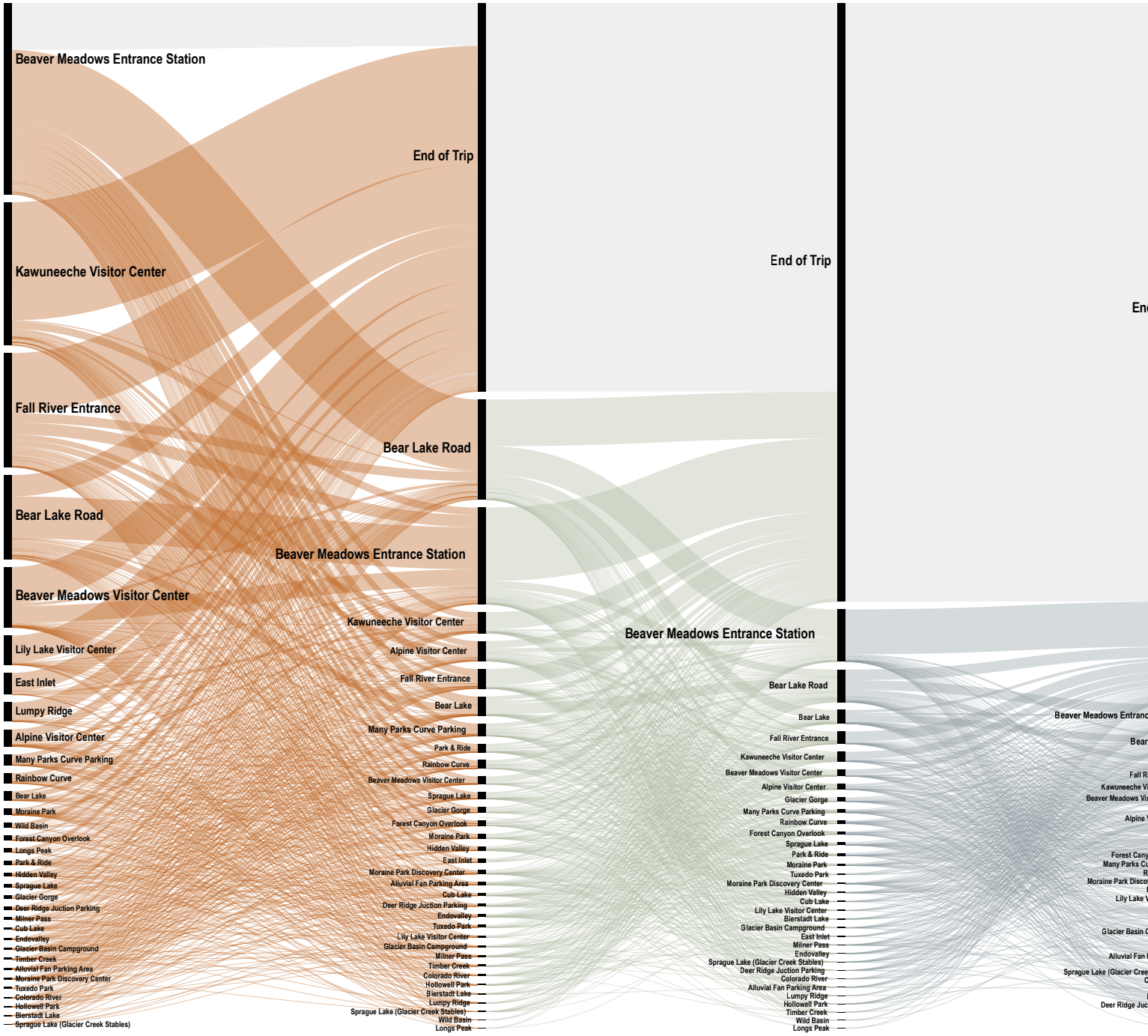
Figure 8. Total Observed Visits (6-32)



The trip sequence data provided for ROMO is extremely rich, with 99,494 observed internal trip sequences of up to 15 stops across the park. However, activity in this dataset is strongly concentrated at top locations, such as visitor centers, entrance stations, and the Bear Lake Road corridor. While the top destination, the Beaver Meadows Entrance Station, saw more than 50,000 visits, the bottom 15 POIs by destination each saw less than 1,000 trip ends.

The Sanke diagram, shown in Figure 8, illustrates the first seven steps of all observed internal trip sequences within ROMO. While individual travel patterns between POIs can be discerned, more insights can be gleaned by focusing on subsets of the data.

Figure 9. Complete Trip Sequence Data for ROMO (First 7 Steps)



Distributive flow mapping of travel from a given origin to destinations throughout the Park provide a sense of how visitors entering at different locations move through the park and access various attractions. The following maps (Figures 8, 9, and 10) show travel patterns beginning at the Kawuneeche Visitor Center/ Grand Lake Entrance, Fall River Entrance, and Beaver Meadows Entrance (respectively), and proceeding through the park.

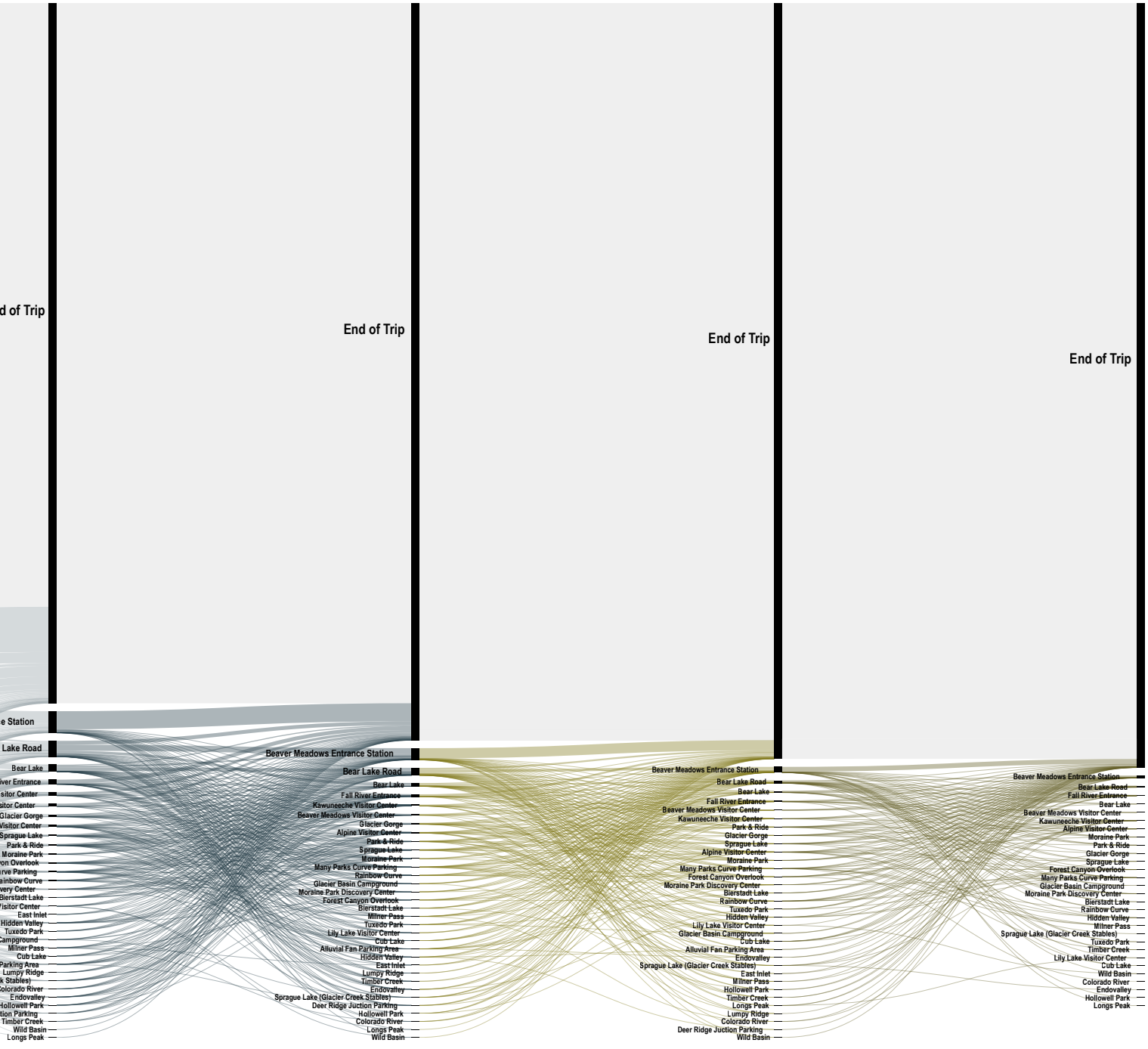


Figure 10. Traffic Flows from Kawuneeche Visitor Center / Grand Lake Entrance

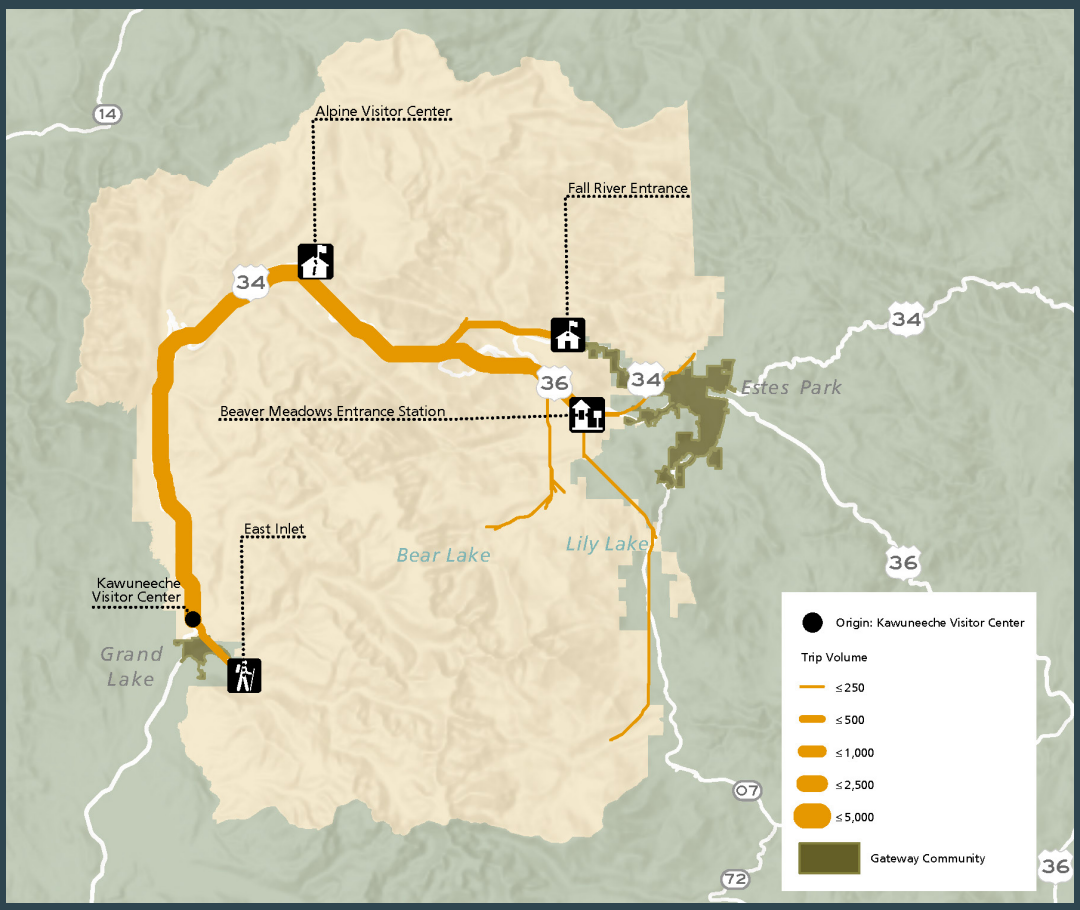


Figure 11. Traffic Flows from Fall River Entrance

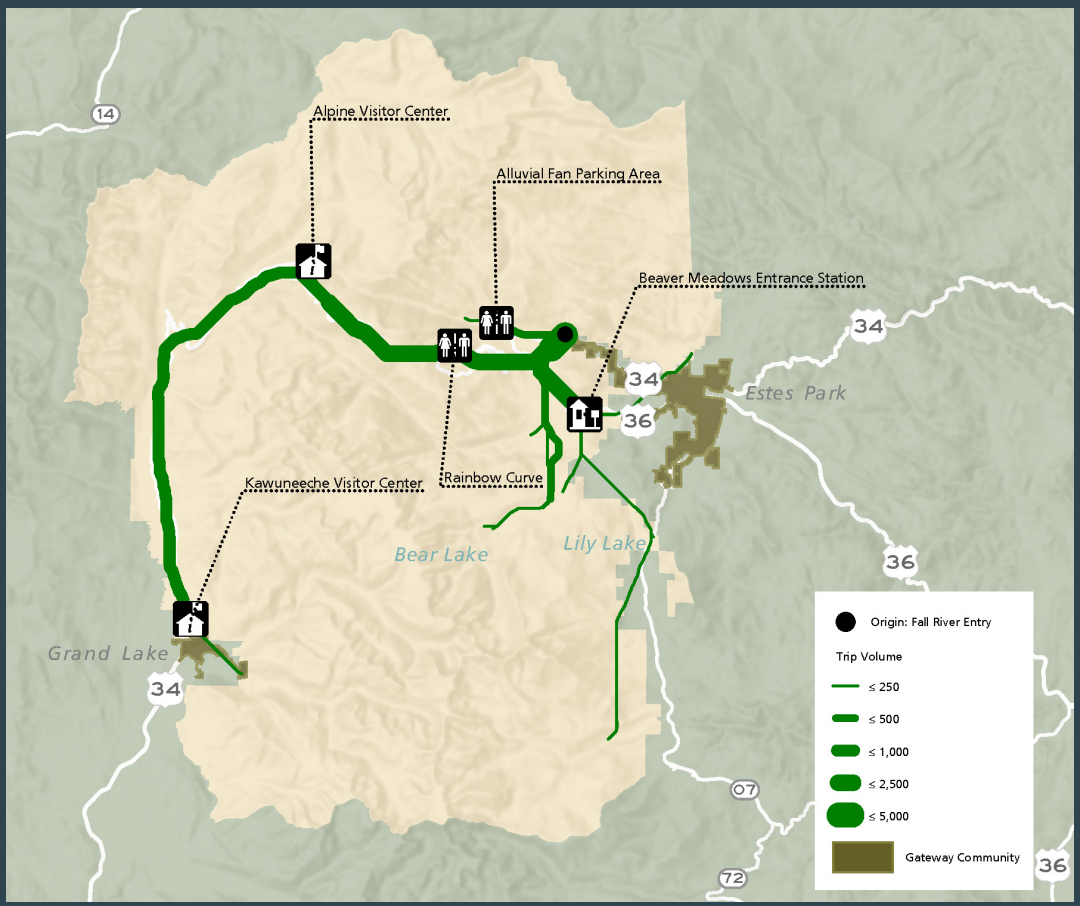


Figure 12. Traffic Flows from Beaver Meadows Entrance

Two patterns are immediately apparent from this data. First, substantial numbers of visitors enter at one of the east entrance stations and proceed over the Trail Ridge Road to exit on the west side, or vice versa, without stopping at any internal destinations. Second, Bear Lake Road and various destinations along that corridor are a major destination, especially for visitors entering the park from the Beaver Meadows Entrance.

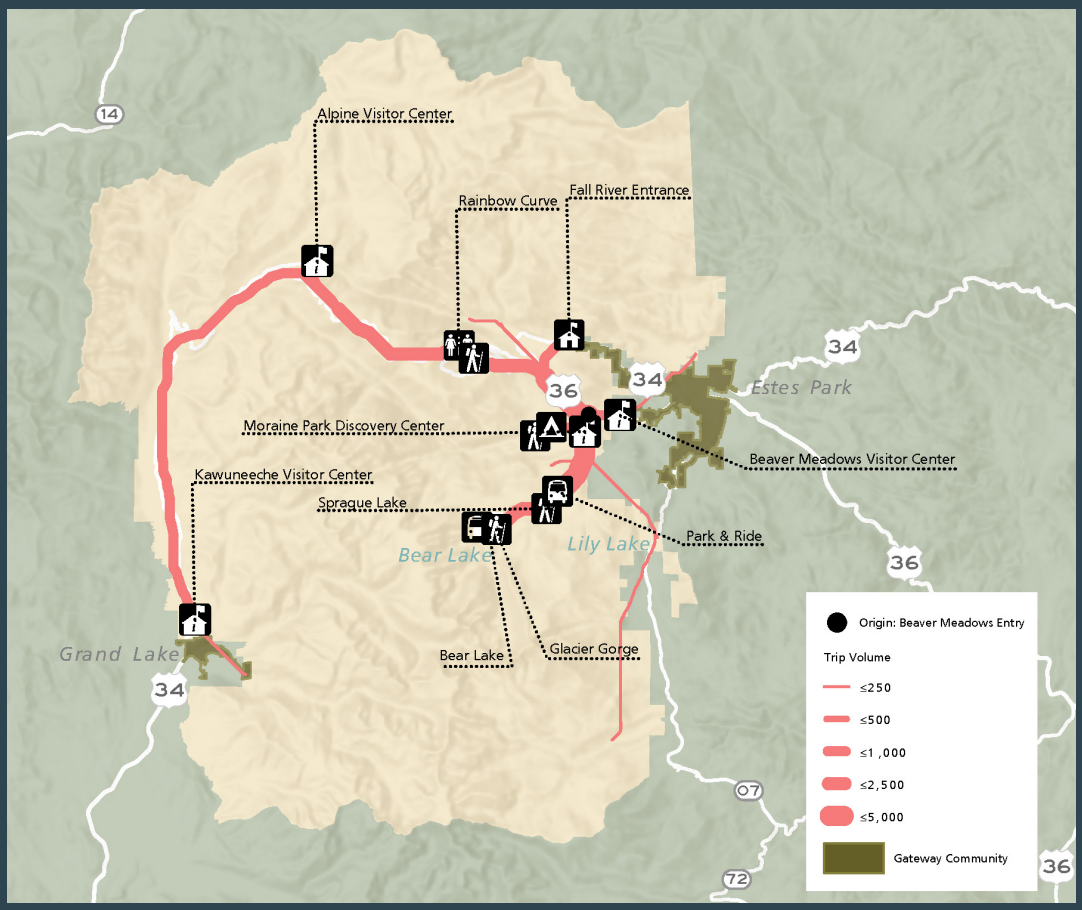
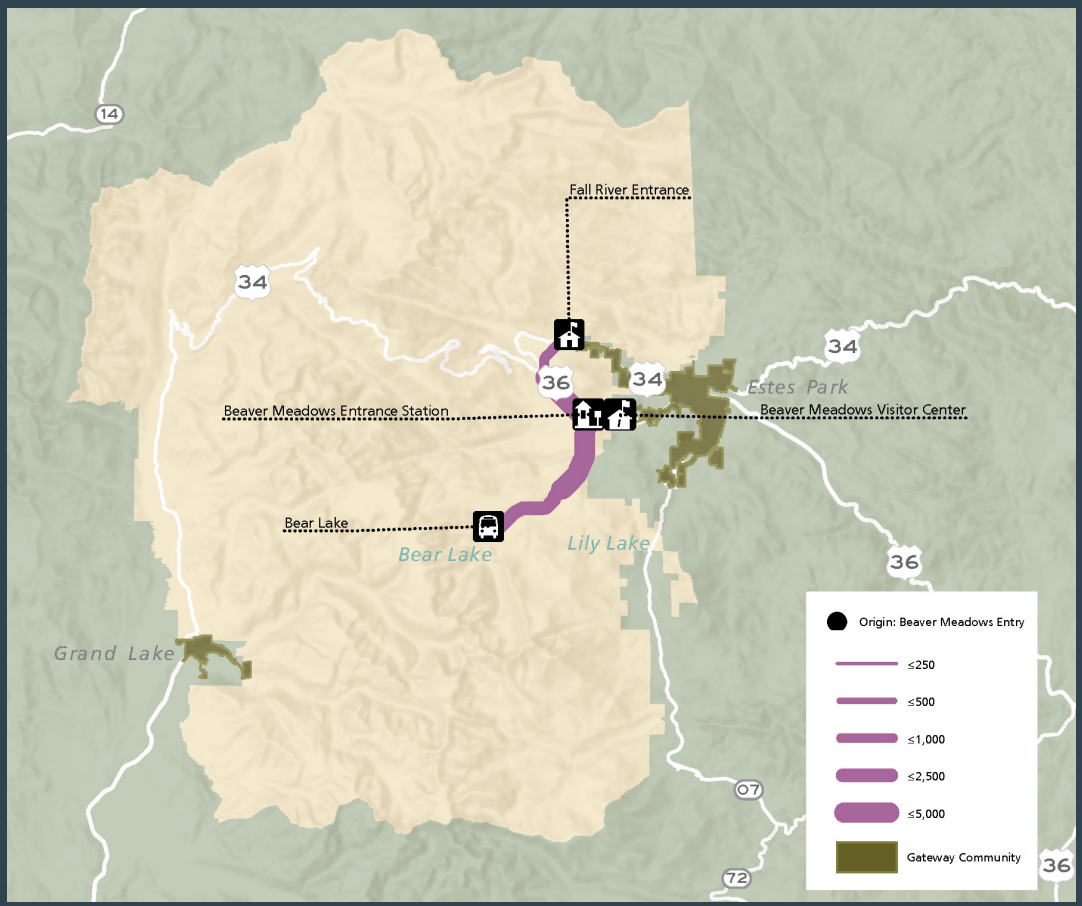


Figure 13. Top 5 Unique Trip Sequences

An examination of common trip sequences is consistent with these observations. For example, the most common unique trip sequence with at least 3 elements is a trip from the Beaver Meadows Entrance to Bear Lake Road and back to the Beaver Meadows Entrance.



Receiving internal trip data in sequential format allows for an analysis of when individual POIs are visited within the course of a visitor's journey through the park. For example, Figure 13 shows the proportion of trips observed as the first, second, third, or fourth or greater stop within trip sequences. Park entries and visitor centers, as well as external sites (e.g. Longs Peak and Wild Basin trailheads) tended to be observed as a first stop within the park, whereas destinations along Bear Lake Road were most likely to be visited as the third, fourth, or higher-order stop within a longer trip sequence.

The largest share of trip sequences in ROMO, 42%, begin during the midday peak period between 10am and 2pm. Approximately a fifth of trips begin in the morning before 10am, while 30% begin during the afternoon peak (2pm-6pm) and 8% in the evening past 6pm. Long trip sequences were more likely to begin during early or peak morning hours (53% of trips with 7 or more stops), whereas trips with one or a few stops were much more likely to begin after 2pm through the evening (43% of single-stop trips).

An analysis of destinations by residency also provides information on which destinations are most visited by in-state or out of state residents. Colorado residents were most disproportionately likely to be observed at Moraine Park, as well as other trailheads and campgrounds; conversely, non-residents were disproportionately likely to be observed at visitor centers and scenic overlooks. These patterns may reflect on the degree of familiarity and desired activity types of residents compared to out-of-state visitors.

Figure 14. Order of Visit by Park Area

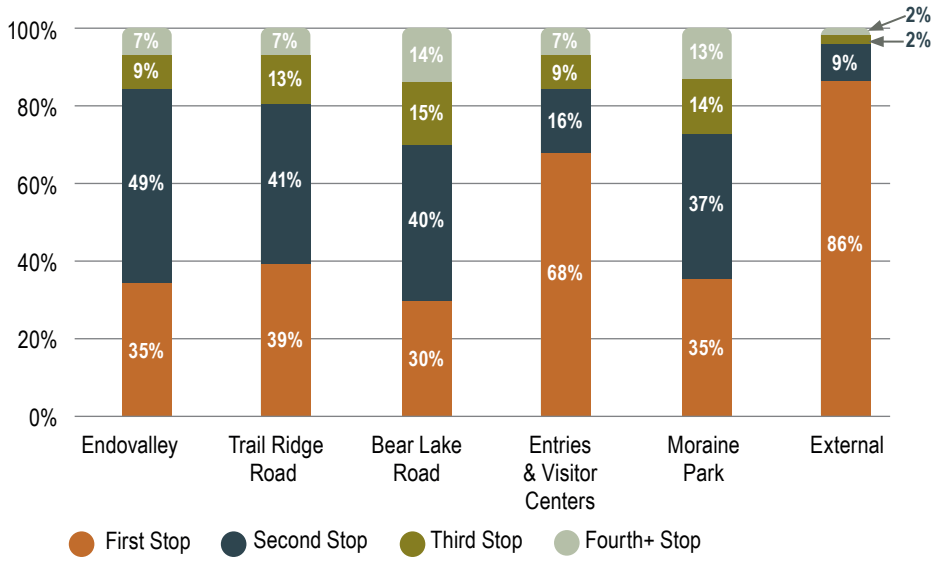


Figure 15. Analysis of Destinations by Residency

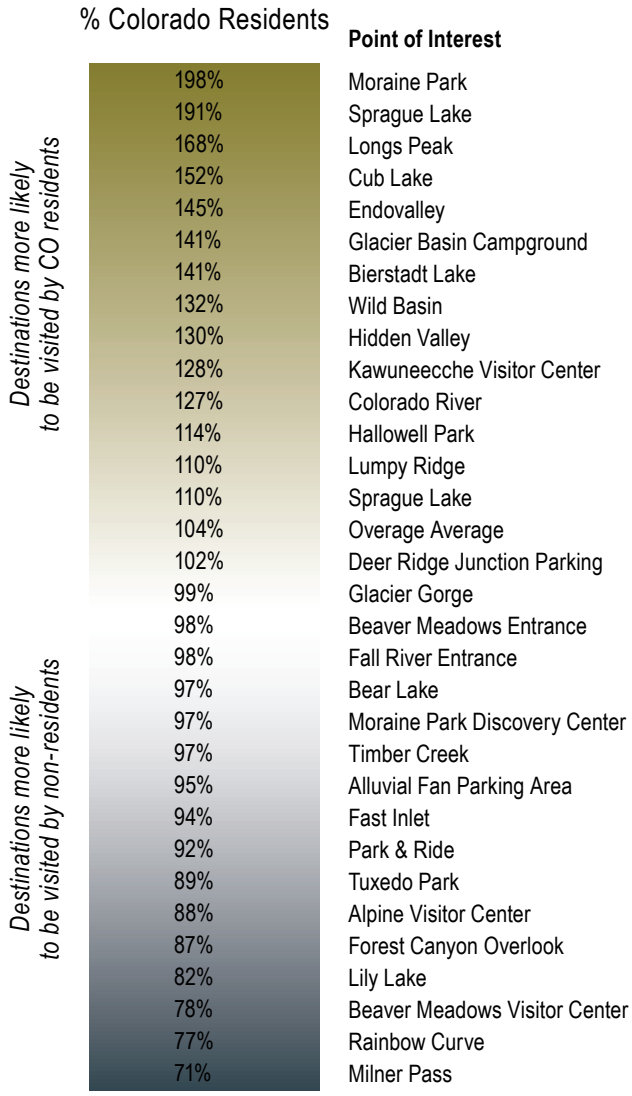
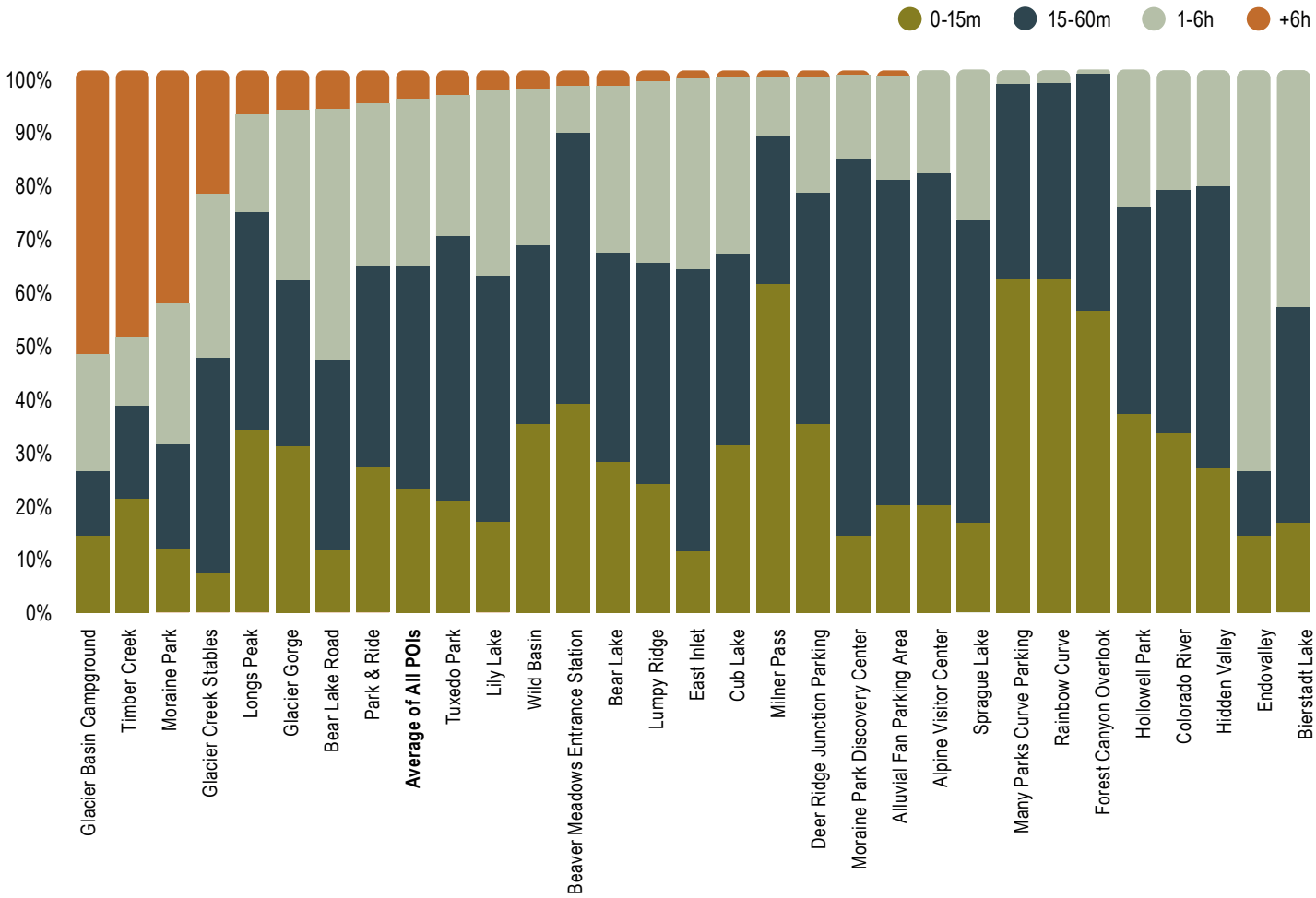


Figure 16. Dwell Times by ROMO Point of Interest



INTERNAL DWELL TIMES

Dwell times were calculated for each of the POIs in ROMO included in the internal trip sequences above.

ROMO sites with the greatest internal dwell times were the Glacier Basin, Timber Creek, and Moraine Park campgrounds, all with average dwell times of 7-9 hours. Sprague Lake (Glacier Creek Stables) experienced the longest non-campground dwell times at nearly 5 hours, while Bear Lake Road, Longs Peak, the Park & Ride, Tuxedo Park, and Glacier Gorge all experienced dwell times between 1.5-2.0 hours.

Examining the detailed dwell time bins provided in the dataset shows very large differences in the distribution of time spent at different locations by visitors. The table below shows the proportion of visits that fall into 0-15 minute, 15-60 minute, 1-6 hour, or >6 hour dwell time bins. At the far end of the distribution, nearly 2/3rds of visitors to Many Parks Curve spend less than 15 minutes at this scenic overlook; many other scenic overlooks see similarly high proportions of short visits. (Due to greater probabilities of short stops being incorrectly excluded from the dataset as a stop than of longer stays being subject to the same errors, these estimates may understate the proportion of visitors making short visits to some locations.) Conversely, campgrounds within the sample see high proportions of stays over six hours, aligning with overnight stays by campers in these locations. Outside of campground locations, stays of over 6 hours at any given POI are quite uncommon.

Because Bear Lake Road was treated as a destination as well as individual POIs along the corridor, dwell times for Bear Lake Road and individual destinations along the corridor may differ.

The destinations with the highest shares of visits in each of these time bins include:

Highest Shares of 0-15 Minute Stays

» Many Parks Curve Parking (62%)
» Rainbow Curve (61%)
» Milner Pass (61%)
» Forest Canyon Overlook (56%)
» Beaver Meadows Visitor Center (38%)

Highest Shares of 15-60 Minute Stays

» Alpine Visitor Center (61%)
» Alluvial Fan Parking Area (60%)
» Moraine Park Discovery Center (58%)
» Sprague Lake (55%)
» Endovalley (54%)

Highest Shares of 1-6 Hour Stays

» Bear Lake Road (46%)
» Bierstadt Lake (43%)
» East Inlet (35%)
» Lily Lake (34%)
» Lumpy Ridge (33%)

Highest Shares of >6 Hour Stays

» Glacier Basin Campground (52%)
» Timber Creek (49%)
» Moraine Park (43%)
» Sprague Lake (22%)
» Longs Peak (8%)

Differences between Colorado residents and non-residents were also apparent in the length of time spent at points of interest. For example, average dwell times of residents were over an hour greater than those of non-residents at the Timber Creek and Glacier Basin campground areas, as well as at the Long's Peak and Tuxedo Park trailheads. Conversely, non-residents tended to spend more time at the Moraine Park Discovery Center, and Bierstadt Lake and Lumpy Ridge trailheads.


NO PETS
BEYOND
THIS POINT

5. EXTERNAL TRAVEL FOCUS – ROCKY MOUNTAIN NATIONAL PARK

OVERVIEW

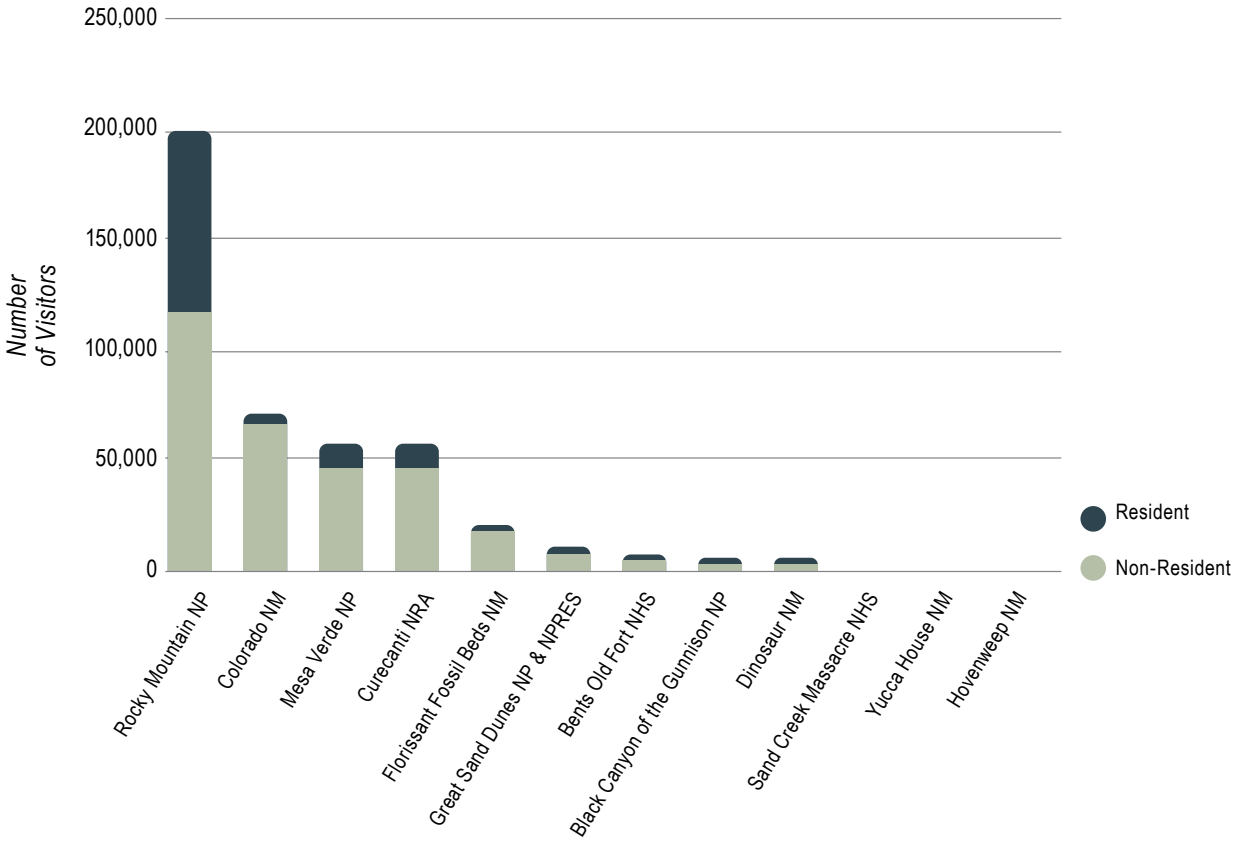
In order to explore the range of questions that mobile device data can shed light on in transportation planning and visitor use management applications, the project team conducted a deep dive into the data available for Rocky Mountain National Park (ROMO). The prior section examined internal travel patterns within this park; in this section, we examine external travel data obtained in and around ROMO, including origin-destination data, congestion data, and gateway community dwell times.

EXTERNAL ORIGIN-DESTINATION DATA

Looking at all trip activity observed going to and from each park, ROMO stands out as the NPS unit experiencing the highest levels of trip activity to and from the park to gateway communities, other parks, and Colorado Welcome Centers. It also has the highest level of non-resident visitation. The sample of 201,830 trips corresponds to just over 2% of annual visitation to the Park.


Rocky Mountain National Park

Figure 17. Trip Activity by Park and Residency Status



As shown in Figure 17, two thirds of these visitors entered and exited ROMO through Estes Park, with Grand Lake being the second most popular gateway community at 16.9%. The Denver Metro was the third most popular gateway community with 12.4% of visitors traveling to and from ROMO. All other Gateway Communities accounted for the remaining 4% of travelers, including travelers who arrived via any of the Colorado Welcome Centers.

It is worth noting that many residents' home locations are likely in the Denver metro area or other populated parts of the Front Range; however, trips in this data sample are treated as originating at the nearest gateway community visited (e.g., Denver Metro visitors who pass through Estes Park on the way to ROMO will be treated as making one trip from Denver Metro to Estes Park followed by a second trip from Estes Park to ROMO in this dataset.) Depending on the goals of an individual study, origin locations could be analyzed in a different manner in order to shed light on trips that may originate in one geography of interest and pass through others on the way to a park or other destination. Additionally, home locations of park visitors can be inferred and reported at county-level or similar geographies, so long as sample sizes are adequate to provide anonymity of individual visitors.

Compared to the peak summer season, resident visitation decreased by roughly 60% in the off-peak season, while non-resident visitation decreased by about 80%. During the off-peak season, Colorado residents make up at least 2/3 of the visitors to gateway

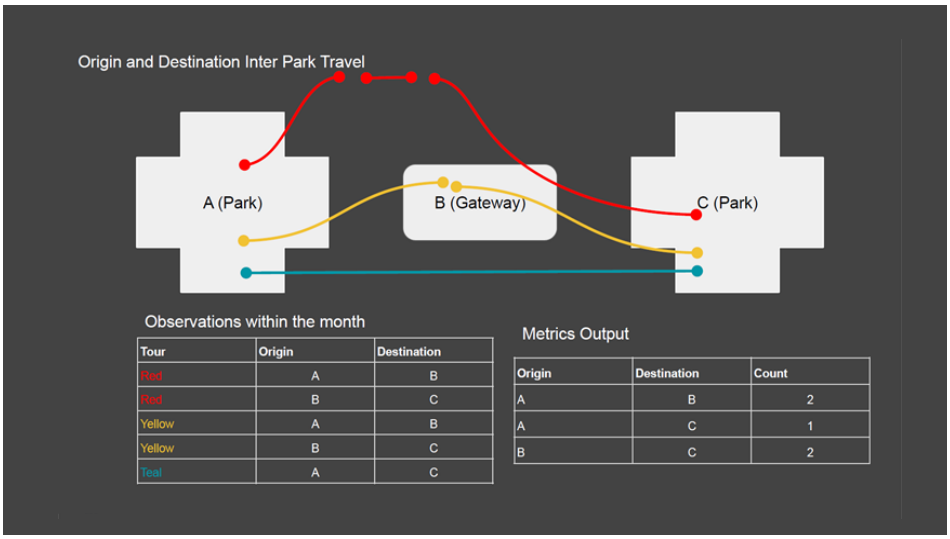


Figure 18. Rocky Mountain National Park: External Gateway Linkages

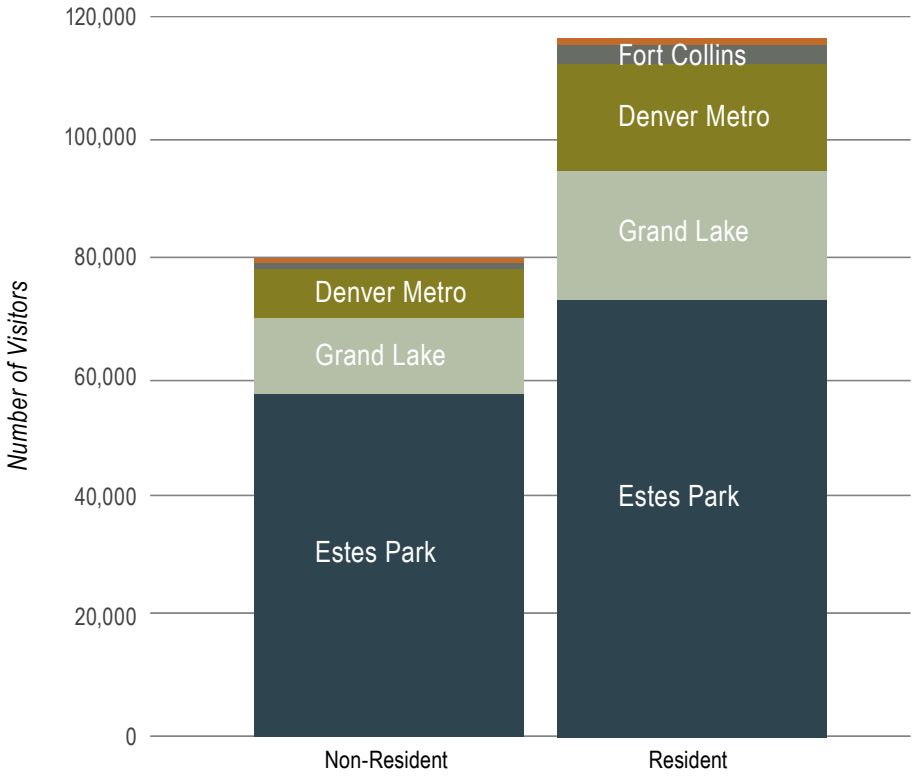


Figure 19. Rocky Mountain National Park as Destination Region Map

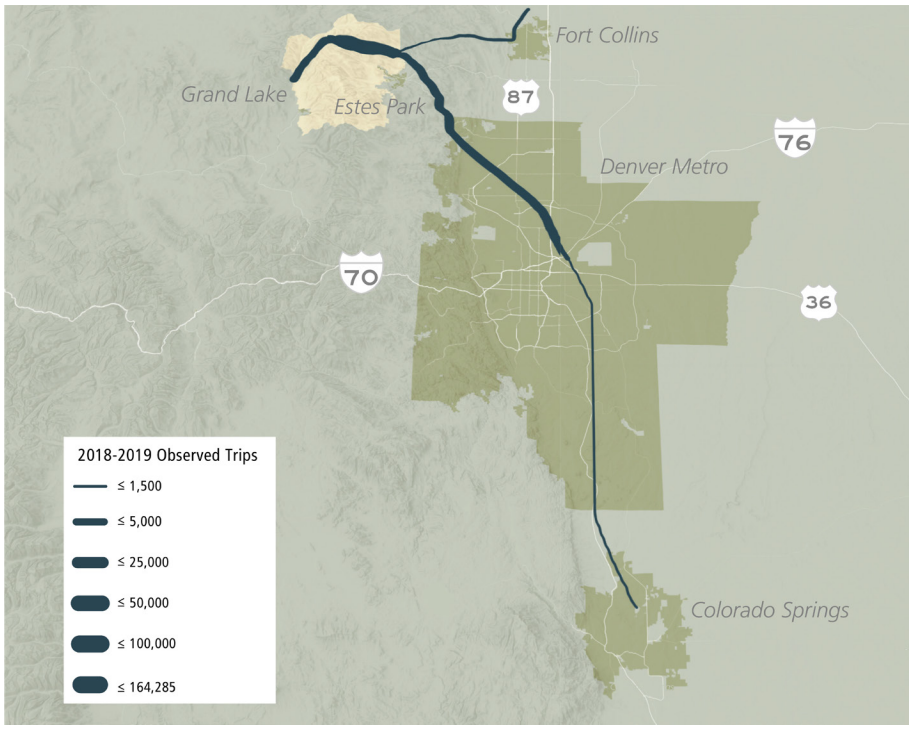
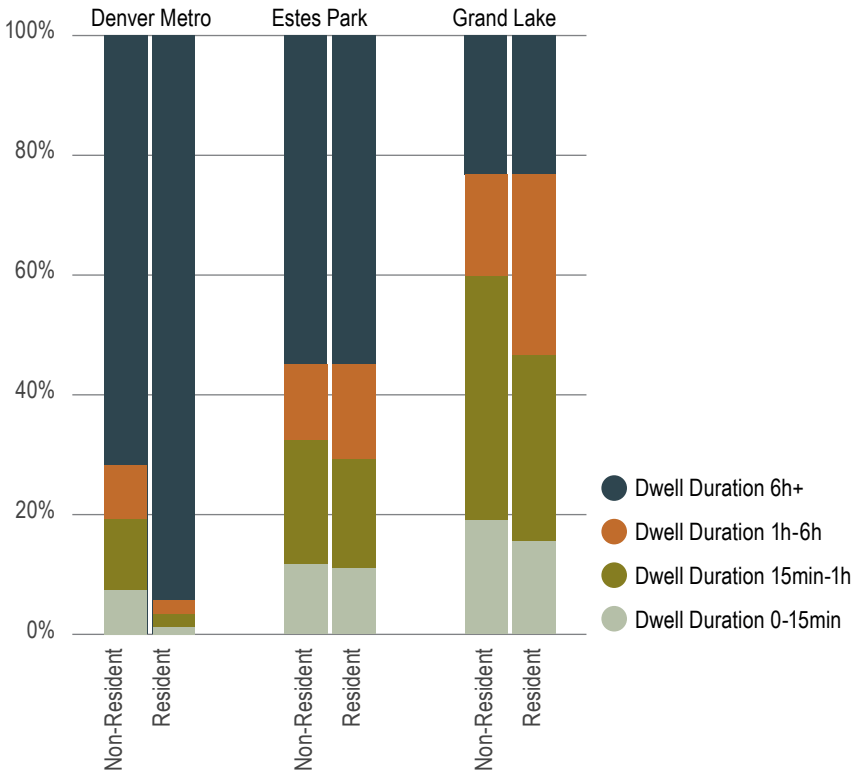


Figure 20. Dwell Times - Resident vs. Non-Resident by ROMO Gateway Community



communities, while typically in the peak season, they compromise about half of the visitors. In the peak season, there are slightly more Colorado residents visiting the Gateway Communities than non-residents, however Estes Park sees more non-residents than residents on weekdays (residents again take the lead on weekends). This may be due to residents' ability to make shorter weekend trips to the Park, while out-of-state visitors may typically make longer, week-long or midweek trips.

Across the five gateway communities that contribute the most trips to ROMO, all of these communities see the highest levels of ROMO-linked visitor activity during the midday peak (10am-2pm), with 2pm-6pm as a close second peak period.

EXTERNAL DWELL TIME DATA

In addition to visitor dwell times at external points of interest, the dwell time dataset obtained from StreetLight Data included time spent at gateway communities. All dwell times reported for external locations are reported only for devices that have entered an NPS unit in the prior month. Therefore, all dwell time data can be considered to relate to National Park visitors, but not every dwell time data point necessarily corresponds to a specific National Park visit, as visitors (especially Colorado residents) may previously or subsequently spend time in a gateway community unrelated to their trip to a park.

Estes Park and Grand Lake see the majority of ROMO's visitor, but the two gateway communities experience substantially different dwell time

distributions. Estes Park visitors tend to stay for long periods of time, with over two gateway communities experience substantially different dwell time distributions. Estes Park visitors tend to stay for long periods of time, with over 70% of visitors staying for 6+ hours, likely indicating an all-day or overnight stay. Grand Lake on the other hand experiences a more distributed array of dwell times with only about 40% of visitors staying for 6+ hours, with another roughly 25-30% staying 1-2 hours. These distributions are similar between residents and non-residents.

The Denver metro area, however, experiences a difference in the amount of long stays (6+ hours) for Colorado residents versus non-residents. While both residents and non-residents tend to primarily stay in the Denver area for 6+ hours, about 15% more Colorado residents stay for a long duration than non-residents. This is unsurprising, given that many of these Colorado residents live and/or work in the Denver area.

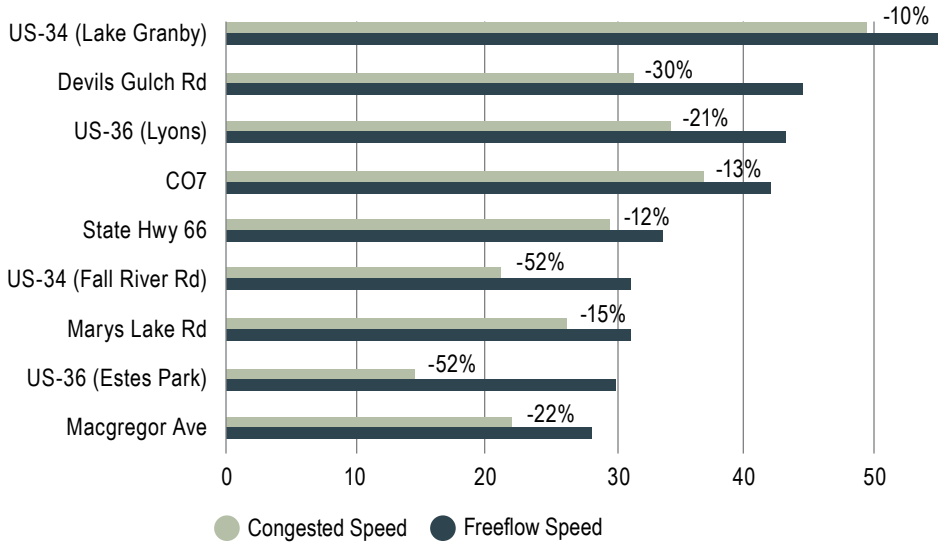
Visitors are observed making fewer long stays (6+ hours) during the off-peak season compared to the peak season, likely due to reduced long-term tourism and vacations. The Denver metro area in particular experiences a decrease of roughly 25% in longer stays for non-residents during the Off-Peak season. Similarly, the weekend days (Saturday & Sunday) experience fewer long-term stays of 6 or more hours, likely due to visitors making day trips or visitors hopping between sites on their days off. However, for both weekend days and the off-peak season, long term stays make up the majority of dwell time data points in Estes Park and the Denver metro area. By contrast, those longer stays make up just 25% of stops in Grand Lake during that time. This might be caused by a higher proportion of residents and workers in Estes Park and Denver.

EXTERNAL CONGESTION

As the most visited National Park in Colorado, the external roadways into ROMO can experience heavy vehicular traffic, as shown in Figure 19. Congestion data shows that US-36 from Estes Park to Beaver Meadows experiences the heaviest congestion of all the study roadways, with congested speeds at nearly half the speed of freeflow periods. Similarly, US-34 near Estes Park also experienced severe congestion, with congested speeds at 68% of freeflow speeds. Conversely, US-34 (Lake Granby) experiences the least impactful congestion with congested speeds causing only a 10% reduction in freeflow speeds.

In addition to StreetLight data, more detailed congestion data was obtained from INRIX Analytics. This data provides detailed information on the location, frequency, duration, and severity of congestion on a specified corridor. Bottleneck analyses were conducted at locations including US-36 (Estes Park to Beaver Meadow Entrance), US-34 (Estes Park to Fall River Entrance), and US-36 through Lyons.

Figure 21. Freeflow vs. Congested Speeds for ROMO Access Roads



Rocky Mountain National Park

Figure 22. US-36 (Park Entrance Road) Congestion Pattern

This pattern of congestion at the Beaver Meadow Entrance was observed 39 times during 2019, with an average congestion duration of 28 minutes and an average queue length of 1.8 miles. As shown below, congestion at the park entrance continues to the intersection of US-36 and Bear Lake Road, which may serve as a bottleneck for left-turning inbound traffic to Bear Lake Road, and can extend all the way to the US-36 and Elkhorn Avenue intersection in Estes Park.

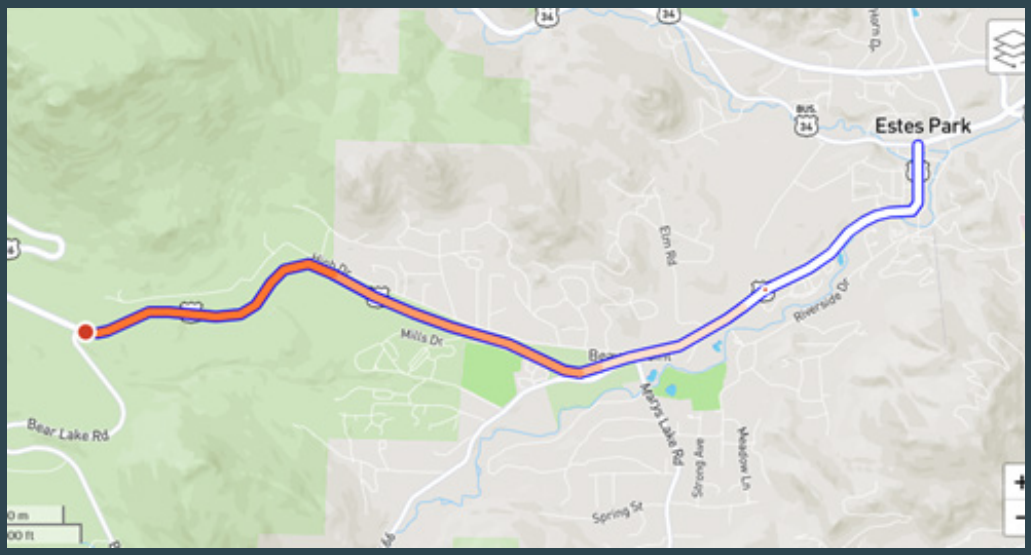


Figure 23. US-34 (Fall River Road) Congestion Pattern

The highest-impact congestion pattern at the Fall River Entrance was observed 31 times during 2019, with an average congestion duration of 30 minutes and an average queue length of 1.2 miles. In this case, congestion is clearly caused by delays at this entrance station, and extend to approximately the location of Sleepy Hollow Court.

Maps provided by INRIX Analytics

Figure 24. US-36 (Moraine Avenue) Congestion Pattern

A frequent but low-intensity area of congestion is located on Moraine Avenue (US-36) in Estes Park. This occurred on a near-daily basis in 2019, with 343 instances recorded. On average, congestion events lasted 10 minutes and had an average queue length of 0.5 miles.

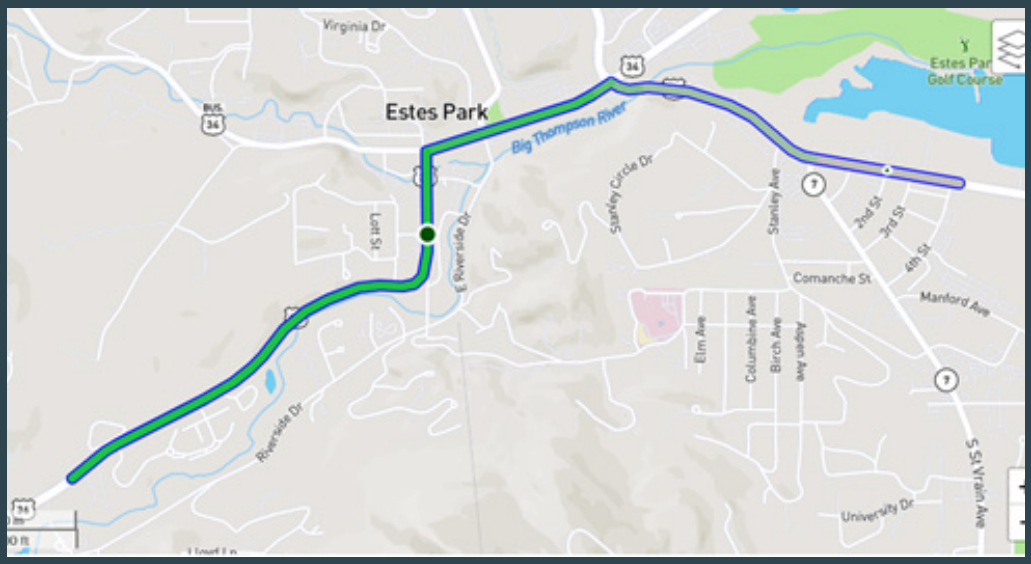
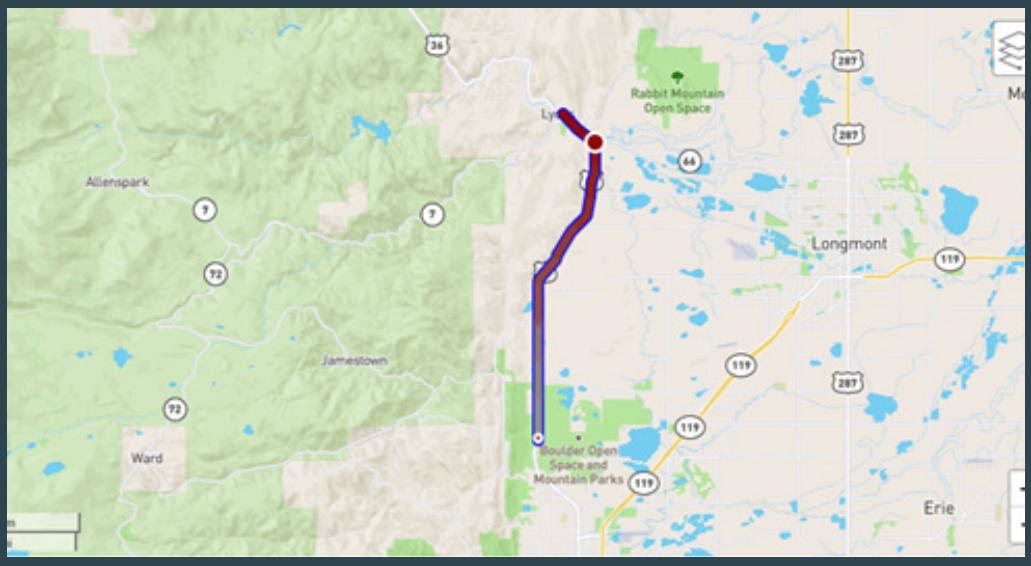


Figure 25. (Main Street, Lyons) Congestion Pattern

The highest impact congestion events in this dataset were located on US-36 through Lyons. This pattern of congestion was observed only 7 times during 2019, but created queues of 6.8 miles from Lyons south to the outskirts of Boulder. This infrequent but high-impact congestion event was concentrated in November and December of 2019, indicating it may be attributable to seasonal factors such as inclement weather, special events, or road work.



Maps provided by INRIX Analytics

6. APPLICATIONS & NEXT STEPS

WORKSHOP

A workshop was held on July 2, 2020 with the full project team in order to review preliminary findings and data and provide a venue for discussion. The workshop included representatives of Fehr & Peers, NPS (regional and Washington offices), CDOT, and the US Department of Transportation Volpe Center. The workshop was originally planned as an all-day in-person session, but due to COVID-19 was shifted to an online format.

Discussions during each of four breakout sessions, as well as a lessons learned concluding session, provided both agency staff and the Fehr & Peers team with valuable information on potential opportunities, obstacles, and consideration for application of mobile device big data sources to current planning and management challenges faced by NPS staff, planners, and other stakeholders. These discussions informed the structure and content of this report, as well as the potential applications discussed below.

APPLICATIONS

Potential applications of big data provided by big data vendors include:

- Traffic assessment and monitoring
- Parking demand assessment and management
- Regional transportation planning
- Visitor use and travel patterns
- Community connections, economic development, and tourism

TRAFFIC ASSESSMENT AND MONITORING

Data products used in this report, including StreetLight travel time and speed data and INRIX congestion and bottleneck reports, can provided detailed historical data on times, locations, and severity of congestion occurring in and around NPS units. Traditionally, congestion mitigation projects have been in response to community or user complains and/or staff observations, followed by data collection and traffic operations analysis. The application of travel time and congestion datasets allows for a more systematic assessment of where and when issues occur in and around a park and may help to make decisions around prioritizing solutions to frequent but low-intensity congestion versus rare but highly impactful congestion.

In future iterations, the project team noted that obtaining speed data in terms of percentiles (e.g. 5th, 15th, 50th, 85th, 95th percentile speeds), rather than proportions of devices in defined speed bins, may be more useful in evaluating congestion as well as evaluating appropriateness of existing speed limits.

Rocky Mountain National Park

PARKING

Dwell time data can provide a valuable lens on parking needs and management strategies. Parking needs and challenges may vary greatly between locations where most visitors arrive early in the day and spend many hours there (such as remote trailheads), compared to locations that see short-duration visits during peak visitation hours (such as scenic overlooks). Detailed data on how parking areas are used can inform policies, strategies, and parking investments, but may be costly and time-consuming to collect through traditional means, especially if understanding differences in behavior over time is important. Mobile device data products can provide cost-effective insight into usage and parking patterns in these areas.

REGIONAL TRANSPORTATION PLANNING

Origin/destination data collected from location-based services provides unique insight into how people travel between destinations at a regional

level, which in turn can provide a deeper understanding of where and what kinds of transportation investments and strategies can best serve the goals and interests of the National Park Service, adjacent communities, the State of Colorado, and visitors.

Understanding the travel behavior and usage patterns of people visiting NPS units can help assess the viability, benefits and trade-offs of strategies. Potential applications include:

- Identifying, defining, and confirming problems;
- Evaluating the viability of transit services to or within parks and gateway communities, based on overall travel market sizes, top origin/destination pairs, tour complexity, and dwell times;
- Identifying key bottlenecks in park or regional roadway networks;
- Understanding year-to-year trends and variation in usage and travel behavior (e.g. 2020 changes in travel patterns and volumes due to COVID);
- Evaluating metering or fee programs to spread demand; and,
- Conducting before/after evaluations of infrastructure and/or policy interventions.

VISITOR USE AND TRAVEL PATTERNS

Understanding the patterns of visitor travel within and surrounding NPS units is a critical application of these datasets. While the data sources obtained in this project are focused on understanding travel patterns (high volume areas, times of day, popular routes, etc), examining specific elements of those patterns, such as dwell time data or high volume travel routes through a park, can provide useful insights about visitor use. Understanding the timing and frequency of visits to specific sites can help guide investments in infrastructure, and in communicating visitor opportunities. Analysis of congestion hot spots, dominant travel patterns, and relative use levels can give us initial information about potential issues related to visitor access, quality of visitor experiences, and use of associated facilities.

COMMUNITY CONNECTIONS ECONOMIC DEVELOPMENT, AND TOURISM

These data sources provide a more comprehensive understanding of visitor travel patterns, and analysis at this level helps the NPS and our partners capitalize on opportunities to increase access to parks and better connect parks to communities. Leveraging mobile device data sources may help parks and their neighboring jurisdictions better understand where visitors are coming from, what routes they travel during a trip to the region, relative use levels at points of interest, and identify congestion hot spots. Additionally, the data can create opportunities for the NPS to work with stakeholders to identify and address shared issues and goals around visitor experience, and collaborate to achieve those goals with a singular, united voice.

National Park Service units provide outstanding economic development opportunities for adjacent stakeholders, but sometimes create challenges for local residents and communities. Origin/destination and dwell time data can help both NPS and state and local officials understand how park visitors interact with gateway communities. Data on the proportion of visitors who travel through gateway communities, and the amount of time spent there, provide a starting point for these discussions.

For state tourism offices and destination marketing organizations, this data assists in understanding where and when to deploy their messages and promotion and in what proportions; potential content for those messages; and how to engage with visitors on the routes to and from destinations. In addition, emerging data vendors focused specifically on tourism and event management may be able to provide more tailored products to these communities, relating travel data to spending data to more directly understand the economic impact of outdoor recreation-linked tourism.

APPENDIX